FEASIBILITY OF INSTALLING NOx CONTROL TECHNOLOGIES

BY MAY 2003

Office of Air and Radiation

Acid Rain Division

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Summary

The proposed Ozone Transport Rulemaking (63 FR 17349), or NOx SIP call, requires that starting on May 1, 2003 each of the 23 affected jurisdictions comply with its ozone season NOx budget. EPA's projections of the NOx controls needed to comply with the proposed budgets include post-combustion controls (SCR and SNCR) and combustion controls. Since implementation of post-combustion controls is expected to take longer than implementation of combustion controls, this paper examines the factors that could affect implementation of SCR and SNCR controls.

Investigations reveal that, in general, single unit SCR and SNCR implementations may be completed in 21 and 19 months, respectively. However, projections reflect that a maximum of six SCR implementations at one plant and ten SNCR implementations at another plant may result from the NOx SIP call. Estimated total time needed to complete these implementations is 34 months for six SCR systems and 24 months for ten SNCR systems.

The availability of operating materials such as SCR catalyst and ammonia or urea reagents, hardware used in construction of the control devices, and skilled labor used in installing the control equipment could affect the time needed to implement the NOx controls. However, as discussed in the main body of the report, the implementation of the NOx SIP call will not be delayed by these factors.

Typically, a SCR or SNCR system would be connected to an electricity generating unit during the regularly scheduled planned outage of about 5 weeks duration. However, analyses were conducted to examine any impacts that may result if a longer than average outage time was needed to install SCR controls on some units. The analyses demonstrated that the stability of the power supply was not threatened and the cost increases, if any, were small, ranging from about 0.0 percent to about 1.6 percent of the cost of complying with the NOx SIP call.

Based on the above considerations, it is estimated that the NOx controls needed to comply with the ozone season NOx budgets can be installed by September 2002, without causing an adverse impact on electricity supply. The installation by September 2002 is premised on the control technology implementation process beginning upon or prior to the final State rule publication in September 1999. A compliance date of May 2003 would provide seven more months (including additional fall and spring outage periods) to allow for any unanticipated delays in the process.

1 Background

The proposed Ozone Transport Rulemaking (63 FR 17349), or the NOx SIP call, requires that starting on May 1, 2003 each of the 23 affected jurisdictions comply with its ozone season[1] NOx budget. These jurisdiction-specific budgets were determined based on: (1) the electricity generating units achieving a region-wide emission rate of 0.15 lb/mmBtu; (2) large ($\geq$ 250 mmBtu/hr) industrial sources achieving 70 percent reduction from 1990 emission levels; and (3) application of Reasonably Available Control Technology (RACT) on medium ($\geq$ 1 ton of NOx per day) industrial sources. The proposed rulemaking also required that the NOx controls needed to achieve the budgets be implemented by September 2002. Public comments on the proposed rulemaking have suggested that the September 2002 implementation requirement may be too optimistic. Therefore, in this paper an implementation date of May 1, 2003 is investigated. Implementation by this date would provide seven more months (including additional fall and spring outage periods) over the September 2002 implementation requirement.

EPA's projections of the NOx controls needed to comply with the proposed budgets include post-combustion controls (SCR and SNCR) and combustion controls. In general, the implementation of combustion controls will not take as much time as implementation of post-combustion controls for the following reasons. First, there is considerable experience with implementing combustion controls. Combustion control retrofits on over 230 utility boilers, accounting for over 75 GW of capacity under the Title IV NOx program, took place within 4 years (i.e., from 1992 through 1995). Moreover, the combustion retrofits under Phase I of the Ozone Transport Commission's Memorandum of Understanding were completed in the same time frame. As a result of this experience base, the sources and permitting agencies are very familiar with the installation of combustion controls. This familiarity will result in relatively short time frames for completing technology installations and obtaining relevant permits. Second, combustion controls are constructed of commonly available materials such as steel, piping, etc. and require no reagent during operation. Therefore, delays due to material shortages are not expected to occur at sites implementing these controls. Third, there are many vendors of combustion control technology. These vendors should have ample capacity to meet the NOx SIP call needs as they were able to satisfy the significant installation needs over the period 1992 through 1995 mentioned above and since then have had relatively few installation needs to fill. For these reasons, it is reasonable to expect that implementation of post-combustion controls, not combustion controls, would determine the schedule for implementing all of the projected NOx controls.

This paper investigates the feasibility of implementing the projected post-combustion NOx controls by May 2003. Specifically, the paper examines the time required to implement these controls at plants with single and multiple installation requirements, the availability of control technology equipment, the availability of labor needed to install the controls, and the impact of outages at electricity generating plants for completing control technology installations. In determination of the proposed jurisdiction-specific budgets, the NOx

[1] The summer ozone season is from May 1 to September 30.

reduction efficiency of SNCR on electricity generating units was assumed to be 40 percent (for low-emitting sources, with baseline emissions below 0.5 lb/mmBtu). Comments on the proposal suggest that this efficiency may be between 30 to 40 percent. Consequently, also examined in this paper is the impact of assuming 30 percent reduction efficiency for SNCR applications on low-emitting electricity generating units.

The analysis conducted in Sections 2 through 7 is based on the proposed NOx SIP call. Since the proposal, EPA has revised the NOx budgets for each of the affected jurisdictions. This has resulted in revised projections of post-combustion control retrofits on electricity generating units and industrial boilers. The effects of these revised projections are explained in an Addendum in Section 8. Overall, the conclusions of this report would not change with the revised retrofit estimates, as discussed in the Addendum.

2 Affected Population

EPA's projections of the post-combustion NOx controls on electricity generating units, required to comply with proposed budgets, are depicted in Exhibit 1. These projections were determined using the Integrated Planning Model (IPM) and were based on the electricity generating units achieving a region-wide emission rate of 0.15 lb/mmBtu while trading NOx emissions across the 23 jurisdictions of the SIP call region.

Exhibit 1
Capacity and Number of Electricity Generating Units Projected to Be Retrofitted with SCR and SNCR by 2003 with the Associated NOx Reduction Achieved

NOx Control	Capacity (GW)	Number of Installations	Ozone Season NOx Reduction (1,000 tons)
SCR on coal-fired units	63.3	123	412.1
SNCR on coal-fired units	129.1	504	448.3
SCR on oil/gas-fired units	--	--	--
SNCR on oil/gas-fired units	3.6	15	3.3
Total	**196.0**	**642**	**863.7**

Source: ICF Incorporated Analysis

The projections of post-combustion controls by 2007 on industrial sources, required to comply with the proposed budgets, are depicted in Exhibit 2. These projections were based on large ($\geq$ 250 mmBtu/h) industrial sources achieving 70 percent reduction from 1990 emission levels and application of Reasonably Available Control Technology (RACT) on medium ($\geq$ 1 ton of NOx per day) sources. The projections reflect the distributions resulting from minimizing the cost of controls within each of the 23 jurisdictions of the SIP call region.

Exhibit 2
Number of Industrial Sources Projected
to Be Retrofitted with SCR and SNCR by 2007
with NOx Reduction Achieved

NOx Control	Number of Installations	Ozone Season NOx Reduction (1000 Tons)
SCR on coal-fired sources	119	29.2
SCR on oil/gas-fired sources	179	3.2
SCR on other sources	36	4.1
Total	**334**	**36.5**
SNCR on coal-fired sources	733	39.1
SNCR on oil/gas-fired sources	133	47.9
SNCR on other sources	275	15.8
Total	**1,141**	**102.8**

Source: Supplemental Ozone Transport Rulemaking Regulatory Analysis, U.S. EPA, April 7, 1998.

As shown in Exhibits 1 and 2, the reduction of NOx using post-combustion controls on the industrial sources is approximately 14 percent of the NOx reduced from all sources using these controls. Making up a small portion of the reduction, the controls on the industrial sources will require much smaller amounts of operating materials (reagent and catalyst). Further, in contrast to the much larger control systems needed for the electricity generating units, the smaller control systems on the industrial sources will require less effort (e.g., less fabrication and easier handling of smaller equipment) to install.

Note that the projections of NOx control installations in Exhibits 1 and 2 do not assume any emissions trading between electricity generating units and industrial sources. In practice, if emissions are traded across the 23 jurisdictions between these two source categories, the number of installations may be lower than those shown in Exhibits 1 and 2.

3 Schedule for Installing NOx Control(s) at a Plant

Implementation of a NOx control technology at a plant involves several activities contingent upon each other. These activities may be grouped under the following phases of an implementation project: (1) conducting an engineering review of the facility and awarding a procurement contract; (2) obtaining a construction permit; (3) installing the control technology; and (4) obtaining an operating permit.

Exhibits A-1 and A-2 in Appendix A depict the timelines expected to be followed in completing a typical single unit installation of SCR and SNCR, respectively. These timelines also indicate that completion of some of the activities is contingent upon completion of some other activities. In general, the SCR implementation timeline appears to be driven primarily by the engineering activities (i.e., design, fabrication and construction), while the timeline for implementing SNCR is dependent on regulatory permitting activities (required by some States).

As shown in Exhibits A-1 and A-2, in the first phase of technology implementation, an engineering review and assessment of the combustion unit is conducted to determine the preferred compliance alternative. During this phase, the specifications of the control technology are determined and bids are requested from the vendors. After negotiating the bids, a contract for implementing the NOx control technology is awarded. The time necessary to complete this phase is approximately four months for either SCR or SNCR.

In the second phase, the control technology is installed. This installation includes designing, fabricating, and installing the control technology. In addition, compliance testing of the control technology is also completed in this phase. Most of the construction activities, such as earthwork, foundations, process electrical and control tie-ins to existing items, can occur while the boiler is in operation. The time needed to complete this phase of an implementation project is about 18 months for SCR and about 8 months for SNCR.

An important element of the overall control technology implementation is the time needed to connect, or hook-up, the control technology equipment to the combustion unit. SCR takes slightly longer to connect than SNCR. On average, it takes about three to five weeks to connect SCR (Philbrick, J., et al, 1996; Zomorano, E., et al, 1994; and Gregory, M., et al, 1997). As discussed in Appendix B, a German SCR system supplier installed SCR on a significant portion of the German capacity within outage periods consisting of less than four weeks (Correspondence No. 2). In contrast, it takes about one to two weeks to connect SNCR (NESCAUM, 1997, page 123). Electricity generating facilities would be able to plan the connection to occur during planned outages to avoid additional downtime. Because peak electricity demand generally occurs during the summer months (May through September), Exhibits A-1 and A-2 show the connection of control technology equipment to combustion unit occuring during other months. Note that sources in States where peak demand does not occur during the summer months will have more time to connect the relevant controls. Also, since industrial sources do not dispatch electricity, they presumably would be able to implement SCR or SNCR in any time period in a year.

Before the actual construction to install the technology can commence, the facility must receive a construction permit from the applicable State or local regulatory authority. The construction permit process requires that the facility prepare and submit the permit application to the applicable State or local regulatory agency. The State or local regulatory agency then reviews the application and issues a draft approval. This review and approval process is estimated to take about six months. The draft construction permit is then made available for public comment. After any necessary revisions, a final construction permit is issued. Therefore, as seen in Exhibits A-1 and A-2, the total estimated time to obtain the construction permit is approximately nine months (Communication No.1).

Facilities will also need to modify their Title V operating permit to incorporate the added control devices and the associated reduced emission limits. In some States, an interim air operating permit may need to be obtained, until the Title V permit is modified. The operating permit modification process consists of preparation and submission of the application to the applicable State or local regulatory agency. As shown in Exhibits A-1 and A-2, this process can occur simultaneously with the processing of the construction permit application. The process of transitioning from the construction permit to the operating permit varies among States and appears to be somewhat unclear due to the infancy of the Title V operating permit process. Nonetheless, based on discussions with several States, the application review process is estimated to take approximately 38 weeks. The Title V operating permit must also be made available for public comment. The Title V operating permit is then not made final until compliance testing on the control device is completed. Therefore, the total estimated time to modify the Title V operating permit is about 12 months, plus the additional time to complete compliance testing (Communication No.1).

Based on the estimated time periods needed to complete each of the four phases described above, the estimated time period to complete the implementation of SCR and SNCR on one combustion unit is 21 months and 19 months, respectively. This time period is shown in Exhibits A-1 and A-2. See also Communication No. 9.

EPA’s projections reflect that the majority of SCR implementations will involve one to three SCR installations per plant; however, at one facility, six SCR retrofits are projected. Exhibits A-3 and A-4 examine two alternative schedules for retrofitting a facility with multiple (six) SCR retrofits. The first alternative examines the installation of the control device hook-up on a sequential basis, with overlap of compliance testing of SCR system on one unit with hook-up of SCR system with the next unit. The second alternative presents installation of SCR systems on two units at a time. The main difference between these two alternatives is the time estimated to complete the installation. The total implementation time estimated is 33 months for the first alternative (sequential hook-up) and 34 months for the second alternative (two units simultaneously).

EPA’s projections also reflect that at one facility, ten SNCR retrofits may be required. Exhibit A-5 presents a schedule for retrofitting a facility with multiple (ten) SNCR retrofits. The exhibit shows the timing for installation of the control device hook-up on a sequential basis, with overlap of compliance testing of SNCR system on one unit with hook-up of SNCR system with the next unit. The total implementation time is 24 months.

In summary, the total time needed to complete the design, installation, and testing at a facility with one SCR unit is 21 months, at a facility with multiple SCR (six) units is approximately 34 months, at a facility with one SNCR unit is 19 months, and at a facility with multiple (ten) SNCR units is 24 months. Based on these timelines, it is estimated that the NOx controls needed to comply with the ozone season NOx budgets can be installed by September 2002, provided that: (1) an adequate supply of materials and labor is available; and (2) the control technology implementation process begins upon or prior to the final State rule publication in September 1999. A compliance date of May 2003 would provide seven more months (including additional fall and spring outage periods) to allow for any unanticipated delays in the process.

4 Availability of SCR Catalyst, Reagents, Hardware, and Labor

The implementation of post-combustion controls also requires an examination of the availability of associated catalyst, reagents, and hardware. This availability is discussed in the following paragraphs.

SCR Catalyst

SCR systems require a catalyst for NOx removal. The current worldwide capacity of SCR catalyst supply is approximately 43,000 cubic meters/year (m^3/yr) to 67,000 m^3/yr, assuming that two suppliers can provide approximately 6,000 m^3/yr each, one supplier can produce 7,000 m^3/yr, and approximately eight more worldwide suppliers produce between 3,000 and 6,000 m^3/yr. Other potential suppliers were not included in this estimate. These potential suppliers include companies that have supplied SCR catalyst in the past but currently have suspended operations. The potential suppliers also include companies that produce similar types of catalyst and could easily begin to produce SCR catalyst (Communication No. 2).

Currently, the equivalent of approximately 100 GW of coal, oil, and gas-fired capacity worldwide utilizes SCR technology. At these worldwide installations, the volume of SCR catalyst in use is estimated to be approximately 55,000 to 95,000 m^3.[2] Assuming conservatively that 1/12th of the catalyst is replaced each year on average, the current annual demand for SCR catalyst is approximately 5,000 to 8,000 m^3/yr. Note that this estimate of the current annual demand is quite conservative since the catalyst replacement rate on oil- and gas-fired combustion units is likely to be less frequent than 1/12th of the catalyst per year.

Considering the estimated capacity of catalyst supply of 43,000 to 67,000 m^3/yr and the current annual demand of 5,000 to 8,000 m^3/yr, the annual excess capacity is estimated to be approximately 35,000 to 62,000 m^3/yr. The demand for SCR catalyst associated with the NOx SIP call is estimated to be 38,000 to 63,000 m^3 at electricity generating plants and 3,000 to 6,000 m^3 at industrial sources.[3] Therefore, the total demand resulting from the SIP-call is estimated to be 41,000 to 69,000 m^3. It is conservatively expected that installation of SCR catalyst at projected applications would occur over a period of two year. Consequently,

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[2] This estimate is based on the following assumptions for the amount of catalyst required:

Coal-fired application:	0.6 m^3 SCR catalyst/MW to 1 m^3 SCR catalyst/MW
Oil-fired application:	0.5 m^3 SCR catalyst/MW to 0.8 m^3 SCR catalyst/MW
Gas-fired application:	0.2 m^3 SCR catalyst/MW to 0.4 m^3 SCR catalyst/MW

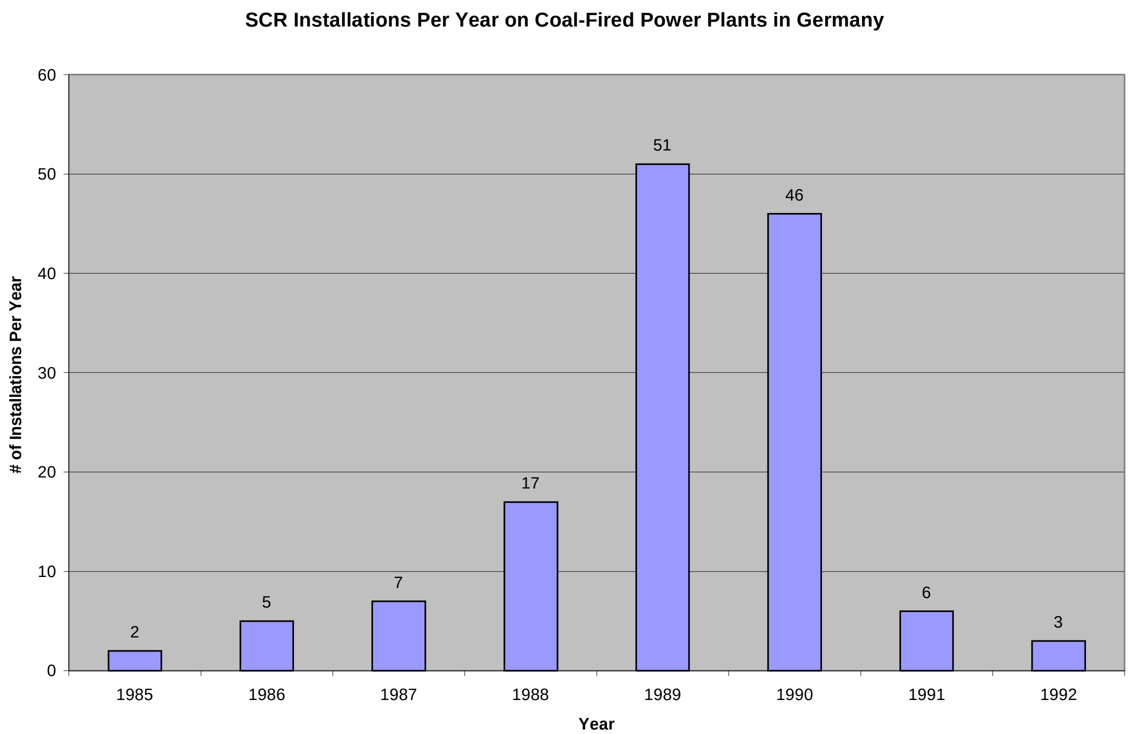
(Communication Nos. 8 and 10).

[3] The estimates for catalyst requirement at industrial sources were arrived at assuming that the required catalyst volume is proportional to mass of NOx reduced and that all of the industrial SCR applications have catalysts similar to coal-fired applications. The NOx reduced (tons) at industrial sources per unit NOx reduced (tons) at the electric generating units was multiplied by the amount of catalyst required at electricity generating units to develop estimates of catalyst required for the industrial sources.

adequate capacity of SCR catalyst supply is believed to be available to satisfy the demand that may result from the projected installations.

The ability to retrofit a large number of SCR systems over a short period of time was exemplified in Germany during the late 1980s. Exhibit 3 shows the number of systems installed over an eight year period, with most of these systems (97 of 137) installed during two consecutive years (1989-1990). This pattern of installations exhibits that the catalyst market demonstrated the ability to respond to the surge in demand resulting from a dramatic increase in SCR installations.

Exhibit 3



Reagents

Ammonia. The installation and operation of SCR systems is not likely to be constrained by the future availability of ammonia. The production of anhydrous ammonia in the U.S. in 1997 was approximately 12,971,000 tons (Communication No. 3).[4] About 234,000 tons per summer season of ammonia will be required for electricity generating plants using SCR and an additional 21,000 tons per summer season will be required for industrial sources.[5] The combined total demand for ammonia of 255,000 tons per summer season is

[4] In the text, all references to "tons" are equivalent to short tons (i.e., 2,000 pounds).

[5] The summer season reduction of NOx, achieved using SCR in Exhibits 1 and 2, was used to estimate the amount of reagent required for electricity generating and industrial sources. The NOx reduced (tons) was

approximately 2 percent of the U.S. production in 1997. Based on these estimates, the supply of ammonia is likely to exceed its demand, even with the additional demand from newly installed SCR systems.

Urea. SNCR systems can use urea or ammonia as a reagent. Recent data suggest that urea-based SNCR systems are more common than ammonia-based systems on electricity generating units. Urea is a commonly available chemical with approximately a 9,921,000 ton domestic annual production capacity (Communication No. 3). Hypothetically, if a 1.1 million ton NOx reduction was achieved entirely by urea-based SNCR systems, about 18 percent (1,800,000 tons) of the annual domestic supply of urea would be consumed by the SNCR systems, assuming overall SNCR reagent utilization to be on the order of about 50 percent (Correspondence No. 1). Since the estimated reduction in NOx using SNCR is approximately half that amount (550,000 tons), SNCR systems will require approximately 9 percent of the domestic supply of urea. Additionally, U.S. urea manufacturers and distributors routinely trade within a 130,000,000 ton worldwide annual production capacity of urea (Correspondence No. 1). Thus, it is expected that this worldwide supply will provide additional flexibility in meeting any significant increases in demand. Note that urea manufacturing is not a specialized process and involves only standard chemical engineering unit operations (Communication No. 4). Therefore, it is expected that plants producing urea would be able to expand their capacity if needed. Based on these considerations, adequate urea supply is expected to be available for the SNCR systems projected in Exhibits 1 and 2.

System Hardware

SCR System Hardware. The hardware items such as steel, piping, nozzles, pumps, soot blowers, fans, and related equipment required for a typical SCR installation are used in large industries such as construction, chemical production, auto production, and power production. Consequently, the NOx SIP call will not result in severe changes in demand for any of the hardware items required for SCR systems. For example, a typical 500 MW SCR installation may require about 500 tons of steel for installation (Communication No. 5); therefore the total estimated amount of steel needed to retrofit the entire projected 63 GW of electricity generating capacity may be about 63,000 tons. Since the U.S. production of steel in 1996 was approximately 105,300,000 tons, the projected 63,000 tons required for retrofitting electricity generating units corresponds to less than 0.1 percent of the U.S. production in 1996 (AISI, 1997). Consequently, steel supply is determined not to be a constraint to the installation and operation of SCR systems. Similarly, available supplies of piping, nozzles, pumps, soot blowers, fans, and other related equipment needed in SCR installations will not present constraints on the ability of facilities to install the technology. It is estimated that approximately 75 ammonia delivery systems can be supplied per year (Communication No. 11). This supply capability is adequate to meet the demand resulting from the NOx SIP-Call.

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converted into the ammonia requirement using the molecular weight of NOx (30), the molecular weight of ammonia (17), and the amount of ammonia required per unit of NOx removed (a 1 to 1 molar ratio).

SNCR System Hardware. Similar to the SCR system hardware, the majority of hardware required for SNCR systems is commonly available. SNCR systems require fewer components than do SCR systems. Storage vessels, nozzles and piping for the reagent storage and delivery system are customary and widely available (Communication No. 4).

Labor

The installation of the NOx control technologies may require the following types of labor:

- general construction workers for site preparation and storage facility installation;
- skilled metal workers for specialized metal and/or other material assembly and construction;
- other skilled workers such as electricians, pipefitters, painters, and truck drivers; and
- unskilled labor to assist with hauling of materials, placing of catalyst elements, and clean-up.

The amount of labor needed for installation of SCR and SNCR technology can be estimated and compared to the unemployment figures to determine whether an adequate labor supply is available. The most recent published data available on employment on a State-by-State basis is for 1996. Exhibit 4 provides a summary of the unemployment figures for the civilian labor force in the construction industry for 1996 for the 23 jurisdictions affected by the NOx SIP call. The civilian labor force includes SIC codes 15 (general building contractors), 16 (heavy construction, excluding building), and 17 (special trade contractors, including electrical work and plumbing). In 1996, the total number of unemployed in this labor category in the SIP call region was approximately 357,000. On a State-by-State basis, the number of unemployed in this labor category ranged from about 1,000 to 55,000 persons. The current (March 1998) national unemployment rate for the construction industry is 8.6 percent (U.S. Department of Labor. 1998, April), which suggests that the unemployment rate in the SIP call region may have come down slightly. However, even with the slight drop in the unemployment rate, an adequate supply of labor for installation of the projected NOx controls is expected to be available, as described below.

Exhibit 4
Employment Status of the Experienced[6] Civilian Labor Force for the Construction[7] Industry 1996 Annual Averages

State	Civilian Labor Force: Construction	
	Unemployed (In Thousands)	**Unemployment Rate (Percent)**
Alabama	9	9.0
Connecticut	8	12.5
Delaware	2	11.8
District of Columbia	(NA[8])	(NA[9])
Georgia	11	7.1
Illinois	33	10.7
Indiana	11	6.5
Kentucky	9	10.7
Maryland	8	5.7
Massachusetts	16	11.4
Michigan	18	9.1
Missouri	16	10.2
New Jersey	23	12.8
New York	55	15.4
North Carolina	15	7.1
Ohio	24	9.4
Pennsylvania	42	16.2
Rhode Island	1	7.8
South Carolina	13	9.5
Tennessee	10	8.1
Virginia	12	6.3
West Virginia	9	19.2
Wisconsin	12	9.0
Total	**357**	**10.3**

Source: U.S. Department of Labor (1998). Geographic Profile of Employment and Unemployment, 1996. "Table 16. States: employment status of the experienced civilian labor force by industry, 1996 annual averages."

The total number of hours of labor needed to install SCR and SNCR under the SIP call requirements is approximately 75 million; 45 million hours for SCR and 30 million hours for SNCR.[9] With a labor year of 2,080 hours, this equates to about 36,000 full-time equivalent workers. Note, however, that the estimated time for the installation of SCR is between 21 and 34 months and the estimated time for SNCR is 19 to 24 months; therefore,

6 Excludes persons with no previous work experience.

7 Construction includes labor categories listed in SIC codes 15, 16, and 17.

8 Data are not shown when the labor force base does not meet BLS publication standards of reliability for the particular area, based on the sample in that area.

9 These estimates are based on the assumptions of 0.708 hrs/kW required for installation of SCR and 0.2225 hr/kW required for SNCR.

the required workload will be spread over several years, and fewer workers will be needed. For example, if workers were to install all SCR and SNCR units over an 18 month period, which is a conservative estimate, 24,000 workers would be needed. This increase in labor corresponds to only seven percent of the 357,000 unemployed workers reported in 1996. A more realistic estimate might be that the workers installing SCR and SNCR would work over several years at various facilities. If all of the SCR and SNCR installations took place over a two to three year period, approximately 12,000 to 18,000 workers would be needed each year, representing three to five percent of the unemployed labor force in the SIP call region.

5 Outage Analysis

In evaluating the availability of outages of sufficient durations and in sufficient numbers for the installation of NOx control systems on electricity generating units, the outage time necessary to connect SCR controls was compared to typical planned outages experienced by coal-fired electricity generating boilers. Particular attention was given to coal-fired boilers within the size range predicted to be controlled with SCR. From IPM runs, it was determined that the average size of a coal-fired boiler projected to install SCR was 512 MW. Exhibit 5 below presents historic outage data and occurrences (i.e., the number of planned outages per year per plant) for coal-fired boilers in the size range from 400 to 599 MW.

Exhibit 5
Historic Outage Data

Year	1992	1993	1994	1995	1996	Average
Planned Outage Hours[10]	958	872	891	793	704	843
Outage (Weeks)	5.7	5.2	5.3	4.7	4.2	5.0
Occurrences[11]	1.42	1.46	1.44	1.32	1.6	1.45

Source: "Generating Availability Data System," North American Electric Reliability Council, July 1997.

As shown in the table, the average outage time is five weeks per year, ranging from 4.2 to 5.7 weeks. Typical activities conducted during planned outages (e.g., removal of slag, repair of boiler tubes, replacement/repair of pumps and motors, and overhaul of turbine(s)) are not expected to hinder the installation of SCR or SNCR technology (Communication No. 6). Literature reports that SCR installations have been completed in three to five weeks (Philbrick, J., et al, 1996; Zamorano, E., et al, 1994; and Gregory, M., et al, 1997). German experiences also demonstrate that typical SCR installations can occur during planned outages of approximately three weeks (Communication No. 7). Therefore, it is reasonable to assume that SCR controls, which typically take from three to five weeks to connect, can be installed

[10] Includes planned outage hours and planned outage extension hours, which are extensions of planned outages. From the data presented, planned outage extension hours are a small fraction of the overall planned outages, and hours are small, typically less than 20 hours per year.
[11] Occurrences are the number of planned outages per plant per year.

without the need for additional outages. This is particularly true if the flexibility of the utilities to dispatch power is considered. For example, utilities could schedule some plants for longer outage periods in a given year and meet power generation requirements from other facilities.

It is uncertain if the decline in planned outage hours shown for 1995 and 1996 is representative of a trend toward reduced outage hours for the industry as a whole. Therefore, additional analyses[12] were performed to ascertain the effects of additional outage requirements, should the trend of declining outage continue. These additional analyses examined the cost and power stability impacts of additional outage requirements to install controls. IPM was used to simulate the impacts of increasing the average outage requirements by two weeks and four weeks. In 2003, IPM assumes that units are unavailable for 8.6 weeks. In light of the historical data presented in Exhibit 5, it is reasonable to assume that five of the 8.6 weeks are planned outages. This analysis also addresses the concerns that have been raised about the time necessary to install controls.

The analyses demonstrate that even in the unlikely scenario of four weeks of increased outage (i.e., a total planned outage of nine weeks) in a single year for every facility projected to install SCR, there are no adverse impacts on power supply. The analyses reflect that adequate generation capacity would be available and existing transmission capacity would be sufficient to cope with the minor regional shifts accompanying the changes in outages. Furthermore, cost impacts, which are shown in Exhibit 6, increase the cost of the rule by about 1.3 percent at most. These costs were found to be related to the need to substitute available, idle power plants for those units taken off line. Because these idle plants are more expensive to run, costs rise slightly.

Exhibit 6
Cost Impacts of Increasing Outage Times from a Five-Week Base Case

Average Outage Time (Weeks)	Cost Impact[13] (Percent Increase in Annualized Cost)
5	0.0 %
7	0.6 %
9	1.3 %

The cost impacts shown in Exhibit 6 are conservative for two reasons. First, to the extent that planned outages for two consecutive years can be combined into a single, longer outage, the need for extending any year's outage will be reduced or eliminated. Thus, the analysis overstates the impacts of any additional outage by what may be a considerable margin. It should also be noted that the analysis assumes the outage requirements are

[12] IPM runs are available at the web site www.epa.gov/capi.

[13] Cost impact is expressed as percent change with respect to annualized cost of the NOx SIP call for electricity generating units based on these units achieving a region-wide NOx rate of 0.15 lb/mmBtu and trading emission allowances across the 23 jurisdictions of the SIP Call.

compressed into a single year. To the extent that utilities will be required to install controls over a multi-year period, the need for additional outages may be reduced, thus reducing the cost impacts. Second, the addition of four weeks of outage (for a total of nine weeks) is believed to be an unrealistically high estimate for the average time necessary to install SCR controls. An average of three to five weeks is believed to be more representative of typical installation times. It should be noted that Germany retrofitted more than 80 percent of its coal fired-power plants with SCR in a three year period. The retrofitted, coal-fired plants represented about 33 percent of the overall generation capacity of Germany, compared to 27 percent in this rulemaking. These SCR units were installed in the typical three week outage period, which was also typical for the German utilities (Communication No. 7).

A second analysis was performed concerning the number of occurrences in the historic outage data. These data indicate that about two-thirds of the plants experience the planned outage in a single block of time, while the remainder experience the outage in two or more periods. For this analysis, it was assumed that two thirds of the facilities experienced the outage as a single five week period, and the remaining third experienced the outage as one three week period and another two week period. Exhibit 7 presents the cost impacts associated with increasing planned outages over this base case.

Exhibit 7
Cost Impacts of Increasing Outage Times Considering Outage Occurrences

Average Outage Time (Weeks)	Cost Impact (Percent Increase in Annualized Cost)
5	0.2 %
7	0.9 %
9	1.6 %

Again, this analysis is very conservative in that all of the outage requirement allocated to the installation of controls is taken in a single year. Also, for those plants assumed to experience a planned outage in a three week period and one in a two week period, it was assumed that the three week period would be expanded for the installation of controls and that the two week outage could not be used for the installation of the controls.

Overall, because installation of controls is likely to be spread over a multi-year period, the amount of outage required to install controls is unlikely to increase significantly over the typical amount of planned outage. This is because it is possible to stretch work over two or three outages (Correspondence No. 2). However, these analyses demonstrate that even if the typical planned outage needs to be extended, the impacts are likely to be minimal. Under no case analyzed did increasing the amount of planned outage threaten the stability of the power supply (deduced from the fact that no new units were built in IPM simulations). In the cases analyzed, cost increases were small, ranging from about 0.0 percent to about 1.6 percent.

6 Change in SNCR NOx Reduction Efficiency

As discussed before, the contributions to the proposed budgets from the electricity generating units were determined using IPM. In this determination, the NOx reduction efficiency of SNCR on electricity generating units was assumed to be 40 percent for low-emitting sources with baseline NOx emissions below 0.5 lb/mmBtu. Public comments on the proposal suggest that this efficiency may be between 30 percent to 40 percent. Therefore, also examined in this paper is the impact of assuming 30 percent reduction efficiency for SNCR applications on low-emitting electricity generating units.

Projections of the post-combustion NOx controls on electricity generating units, assuming 30 percent reduction efficiency for SNCR applications on low-emitting sources, are depicted in Exhibit 8. These projections were determined using the IPM and were based on the electricity generating units achieving a region-wide emission rate of 0.15 lb/mmBtu while trading NOx emission allowances across the 23 jurisdictions of the SIP call region.

Exhibit 8
Capacity and Number of Electricity Generating Units Projected to Be Retrofitted with SCR and SNCR by 2003 with Associated NOx Reduction Achieved (SNCR Reduction Efficiency Assumed to Be 30 Percent For Low-emitting Sources)

NOx Control	Capacity (GW)	Number of Installations	Ozone Season NOx Reduction (1,000 tons)
SCR on coal-fired units	93.6	179	569.0
SNCR on coal-fired units	84.5	343	271.8
SCR on oil/gas-fired units	--	--	--
SNCR on oil/gas-fired units	4.0	17	3.3
TOTAL	**182.1**	**539**	**844.1**

Source: ICF Incorporated Analysis

A comparison of Exhibits 1 and 8 reveals that decreasing the NOx reduction efficiency of SNCR from 40 percent to 30 percent results in 161 fewer installations of SNCR on coal-fired units, 56 more SCR installations on coal-fired units, and 2 more SNCR installations on oil/gas-fired units. Further, the total number of SCR and SNCR installations are also lower in Exhibit 8 (539 versus 642). These results reflect that with reduced NOx reduction capability of SNCR, less of SNCR and more of SCR is needed to achieve the required NOx budget contributions. Further, SCR has higher NOx reduction capability than SNCR. Therefore, its increased use results in a reduction in the total number of SCR and SNCR retrofits.

Further examination of IPM projections using an SNCR efficiency of 30 percent revealed that, in general, one to three SCR or SNCR installations per plant would be expected. However, at one plant a maximum of six SCR systems and at another plant a maximum of ten SNCR systems may result. This pattern of installations is quite similar to that obtained using the 40 percent SNCR efficiency. Therefore, the timelines discussed in Section 3 will still be applicable.

The increase in capacity of SCR installations will result in an estimated total demand of 59,000 to 100,000 m^3 for the SCR catalyst. The excess capacity in catalyst supply of 35,000 to 62,000 m^3/yr would be able to meet this demand over an implementation period of two years or more. (See Section 4.) Further, as discussed in Section 4, current supply capabilities of ammonia and urea would easily be able to meet the demand for these reagents resulting from the NOx SIP call. For example, the estimated ammonia demand of 343,000 tons, resulting from SCR applications, is only about 2.6 percent of the U.S. production in 1997. Note that reduced use of SNCR under the 30 percent SNCR reduction efficiency assumption would result in a lower demand for urea (618,000 tons) than that estimated in Section 4. This demand represents about 6 percent of the domestic supply (see Section 4). Also, note that the increase in installation effort for the 56 additional SCR installations will be roughly balanced by the reduction in installation effort for the 159 fewer SNCR retrofits under the 30 percent SNCR scenario. Finally, fewer installations under the 30 percent SNCR scenario may result in fewer outages.

Based on the above examination, the distribution of NOx controls resulting from changing the SNCR reduction efficiency to 30 percent can still be implemented by September 2002, provided the implementation process begins upon or prior to the final State rule publication in September 1999.

7 Conclusions

Based on the estimated timelines for implementing NOx controls at a plant and the availability of materials and labor, it is estimated that the NOx controls needed to comply with the ozone season NOx budgets can be implemented by September 2002, without causing an adverse impact on electricity supply. The installation of SCR and SNCR technology by September 2002 date is premised on the control technology implementation process beginning upon or prior to the final State rule publication in September 1999. A compliance date of May 2003 would provide seven more months (including additional fall and spring outage periods) to allow for any unanticipated delays in the process.

8 Addendum

The analyses presented in Sections 2 through 7 were based on the proposed NOx SIP call. Since the proposal, EPA has revised the NOx budgets for the affected jurisdictions. These revisions will affect the distribution of post-combustion control technology retrofits. The remainder of this section discusses the effects of the revised retrofit estimates.

8.1 Feasibility Analysis with Revised SCR/SNCR Retrofit Estimates

Revised Projections of Post-Combustion Control Technology Installations

Projections of the post-combustion NOx controls on electricity generating units under a revised NOx budget contribution of about 544,000 tons are depicted in Exhibit 9. These projections were made using IPM under the revised budget contribution while trading NOx emission allowances across the SIP call region. Exhibit 10 presents revised estimates of SCR and SNCR retrofits and the associated emission reductions at industrial boilers.

Exhibit 9
Capacity and Number of Electricity Generating Units Projected to Be Retrofitted with SCR and SNCR by 2003 with Associated NOx Reduction Achieved under the Revised NOx Budget Contribution

NOx Control	Capacity (GW)	Number of Installations	Ozone Season NOx Reduction (1,000 tons)
SCR on coal-fired units	72.9	142	465.6
SNCR on coal-fired units	119.2	482	409.7
SCR on oil/gas-fired units	--	--	--
SNCR on oil/gas-fired units	3.8	15	3.3
TOTAL	**195.9**	**639**	**878.6**

Source: ICF Incorporated Analysis

A comparison of Exhibits 1 and 9 reveals that decreasing the NOx budget contribution results in 22 fewer installations of SNCR on coal-fired units and 19 more SCR installations on coal-fired units. The total number of SCR and SNCR installations are about the same (639 versus 642), while the total tons of ozone season NOx emission reductions from electricity generating units is greater (878,600 versus 863,700) under the revised budget contribution.

Timelines for Installing Controls At a Plant

Further examination of IPM projections under the revised NOx budget contribution revealed that, in general, one to three SCR or SNCR installations per plant would be expected at electricity generating units. At one plant, however, a maximum of six SCR systems and at another plant a maximum of ten SNCR systems may result. This pattern of installations is similar to that obtained using the higher budget contribution (see Section 3); therefore, the timelines discussed in Section 3 and presented in Appendix A are still applicable.

Exhibit 10
Revised Number of Industrial Sources Projected to Be Retrofitted with SCR and SNCR by 2007 with NOx Reduction Achieved*

NOx Control	Number of Installations	Ozone Season NOx Reduction (1,000 Tons)
SCR on coal-fired sources	55	31.4
SCR on oil/gas-fired sources	225	79.2
SCR on other sources	1	0.002
Total	**281**	**110.6**
SNCR on coal-fired sources	195	29.3
SNCR on oil/gas-fired sources	--	--
SNCR on other sources	40	12.1
Total	**235**	**41.4**

*Reflects application of 60 percent emissions control to industrial boilers and combustion turbines, and application of emissions control up to a cost cutoff of $5,000 per ton for stationary IC engines and cement kilns (including bituminous coal-fired).
Source: U.S. EPA, Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis, August 17, 1998.

Availability of Materials and Labor

The increase in capacity of SCR installations will result in an estimated total demand of 54,000 to 90,000 m^3 for SCR catalyst. The excess capacity in catalyst supply of 35,000 to 62,000 m^3/yr would be able to meet this demand over an implementation period of two years or more. (See Section 4.) Also, current supply capabilities of ammonia and urea would easily be able to meet the demand for these reagents resulting from the NOx SIP call. The total estimated summer season demand for ammonia is 264,000 tons for electricity generating units and 63,000 tons for industrial boilers. The total combined summer season demand for ammonia (327,000 tons) is only about 2.5 percent of the U.S. production in 1997. Because the total demand for urea would be lower (744,000 tons) under the revised budget than under the proposed budget (as a result of the reduction in SNCR installations), the change in the budget would not change the conclusion that urea demand could be satisfied without difficulty. As discussed in Section 4, the hardware for the technologies is composed of off-the-shelf materials, which are used in large industries; therefore, the supply of these materials is expected to be adequate. For example, the total steel required to retrofit the 73 GW of electricity generating capacity with SCR systems is estimated to be about 73,000 tons or less than 0.1 percent of the U.S. production in 1996.

The amount of labor needed for installation of SCR and SNCR technologies can be estimated and compared to the unemployment figures to determine whether an adequate labor supply is available. The total hours of labor needed to install SCR and SNCR systems at electricity generating units under the revised NOx budget contribution is approximately 79 million--52 million hours for SCR and 27 million hours for SNCR. With a labor year of 2,080 hours, this equates to about 38,000 full-time equivalent workers. Note, however, that the estimated time for the installation of SCR is between 21 and 34 months, and the estimated time for SNCR is 19 to 24 months; therefore, the required workload will be spread over several years, and fewer workers will be needed. For example, if workers were to install all SCR and SNCR units over an 18 month period, which is a conservative estimate, approximately 25,000 workers would be needed. This increase in labor corresponds to only seven percent of the 357,000 unemployed workers reported in 1996. A more realistic estimate might be that the workers installing SCR and SNCR would work over several years at various facilities. If all of the SCR and SNCR installations took place over a two to three year period, approximately 13,000 to 19,000 workers would be needed each year, representing only 3.6 to 5.3 percent of the unemployed labor force in the SIP call region.

Impacts of Outages

The outage analyses discussed in Section 5 are based on very conservative assumptions, namely that all of the SCR retrofits will occur in one year and will require unlikely outage periods of seven and nine weeks to connect the SCR systems. Under these overly conservative assumptions, it was found that the impacts on the cost of complying with the NOx SIP call are quite small and electricity reliability is not threatened (see Section 5). Because of the stringency of these assumptions, it is determined that the changes in outage requirements resulting from the slightly revised NOx budget contribution will not affect the implementation of the NOx SIP call.

As discussed above, the distribution of NOx controls shown in Exhibits 9 and 10 can still be implemented by September 2002, provided the implementation process begins upon or prior to the final State rule publication in September 1999. A May 2003 compliance date would increase flexibility in the schedule and would accommodate any unexpected delays.

8.2 Change in SNCR NOx Reduction Efficiency

As noted above, the budget contribution of electricity generating units has been decreased (by about 20,000 tons or by less than 4 percent of the original budget contribution of approximately 564,000 tons). The distribution of controls shown in Exhibit 9 results from using an SNCR control efficiency of 40 percent (for low-emitting sources, with baseline NOx emissions lower than 0.5 lb/mmBtu) in the IPM simulation conducted to comply with the revised budget contribution. As discussed in Section 6, reducing the SNCR control efficiency from 40 to 30 percent for the low-emitting plants (with baseline NOx emissions below 0.5 lb/mmBtu) in the IPM has an impact on the distribution of control technology retrofits.

To estimate the distribution of controls under SNCR control efficiency of 30 percent for low-emitting sources, an IPM simulation was conducted using the revised budget contribution. The results of this simulation reflect that utilities are expected to install SNCR on 85.9 GW of the coal-fired units and 4.3 GW of the oil/gas-fired units, and SCR on 97.6 GW of the coal-fired units. The SCR installed on 18 MW of oil/gas-fired units is not significant.

A comparison of the above numbers with the capacity estimates in Exhibit 9 reveals that smaller capacity with SNCR installations and greater capacity with SCR installations is projected under the reduced SNCR efficiency assumption. Specifically, a decrease of 33.3 GW of SNCR on coal-fired units and an increase of 24.7 GW of SCR installations on coal-fired units is seen. As expected, with reduced NOx reduction capability of SNCR, less of SNCR and more of SCR is needed to achieve the required NOx budget contributions.

Based on the revised capacities of SCR and SNCR retrofits, the timelines for installing the technologies and the availability of other materials required for the technology retrofits were examined. It was found that, in general, the retrofit pattern for SCR and SNCR is similar to that discussed in Section 3. Therefore, the timelines discussed in Section 3 and shown in Appendix A will still be applicable.

The increase in the capacity of SCR installations (by 24.7 GW) will result in an estimated total demand of 69,000 to 115,000 m^3 for the SCR catalyst. The excess capacity in catalyst supply of 35,000 to 62,000 m^3/yr would still be able to meet this demand over an implementation period of two years or more. Similarly, current supply capabilities of ammonia and urea would easily meet the changes in demand for these reagents resulting from the revised retrofit estimates (see Sections 4 and 8.1). For example, the increase in SCR capacity would result in an additional summer season demand of ammonia of about 3% of the U.S. production in 1997. Note that reduced use of SNCR under the 30 percent SNCR reduction efficiency assumption would result in a lower demand for urea than that estimated in the other analyses discussed above (see Sections 4 and 8.1). Finally, as shown in Section 4, a relatively large pool of unemployed labor force is available; therefore, an ample labor supply is considered to be available to complete the retrofitting of controls.

As discussed above, the implementation of NOx controls resulting from changing the SNCR reduction efficiency to 30 percent, under the revised NOx budget contribution, can still be implemented by September 2002, provided the implementation process begins upon or prior to the final State rule publication in September 1999.

References [14]

American Iron and Steel Institute (AISI) (1997). Annual Statistical Report, Table 23, Page 71.

Babcock-Hitachi K.K. (1996). *Reference List of DeNOx Plant.*

Communication No. 1. Personal communication between Anup Mangaokar, Dib Paul, and Jamie Pierce of ICF and State regulatory agency representatives from Connecticut, Delaware, Indiana, Kentucky, Maryland, and New Jersey, June, July, and August, 1998.

Communication No. 2. Personal communication between Elizabeth Nixon of ICF and Ed Campobendetto of Institute of Clean Air Companies, July 1998.

Communication No. 3. Personal communication between Kevin Blake of ICF and Deborah A. Kramer, Commodity Specialist, U.S. Geological Survey, May 1998.

Communication No. 4. Personal communication between Wojciech Jozewicz of ARCADIS Geraghty & Miller and Vincent Albanese of Nalco Fuel Tech, April 28, 1998.

Communication No. 5. Personal communication between Wojciech Jozewicz of ARCADIS Geraghty & Miller and John Buschmann of ABB Environmental Systems, April 28, 1998.

Communication No. 6. Personal communication between Ravi Srivastava of U.S. EPA and Jim Staudt of Andover Technology Partners, July 24, 1998.

Communication No. 7. Personal communication between Elizabeth Nixon of ICF and Volker Rummenhohl of Steag, July 22, 1998.

Communication No. 8. Personal communication between Wojciech Jozewicz of ARCADIS Geraghty & Miller and Reda Iskandar of Cormetech, Inc., April 29, 1998.

Communication No. 9. Personal communication between Wojciech Jozewicz of ARCADIS Geraghty & Miller and Michael Wax of Institute of Clean Air Companies, April 9, 1998.

Communication No. 10. Personal communication between Wojciech Jozewicz of ARCADIS Geraghty & Miller and John Calvello of Hitachi America, Ltd., April 28, 1998.

Communication No. 11. Personal communication between Wojciech Jozewicz of ARCADIS Geraghty & Miller and Peter Burlage of Peerless Mfg. Co., May 11, 1998.

[14] All referenced personal communication and personal correspondence records are included in Appendix B of this report.

Correspondence No.1. Correspondence from Pat Roman of Nalco Fuel Tech, April 8, 1998.

Correspondence No.2. Letter from Volker Rummenhohl of Steag to US EPA, August 24, 1998.

Federal Register, Volume 62, Number 216. November 7, 1997.

Gregory, M.G., Cochran, J.R., Fischer, D.M. & Harpenau, M.G. (1997). *The Cost of Complying with NOx Emission Regulations for Existing Coal Fueled Boilers*, EPRI-DOE-EPA Combined Utility Air Pollutant Control Symposium; The Mega Symposium Opening Plenary Session and NOx, Washington, DC.

Institute of Clean Air Companies, Inc. (1997, November). *White Paper: Selective Catalytic Reduction (SCR) Control of NOx Emissions*. SCR Committee.

Institute of Clean Air Companies, Inc. (1997, October). *White Paper: Selective Non-Catalytic Reduction (SNCR) for Controlling NOx Emissions*. SNCR Committee.

Mitsubishi Heavy Industries, Ltd (1997). *Mitsubishi SCR System Supply List (All Plants).*

NESCAUM. (June 1998) *Status Report on NOx Control Technology and Cost-Effectiveness for Utility Boilers.*

North American Electric Reliability Council (1997). *Generating Availability Data System*.

Onishi, T., Fujino, T., Yang, S., & Okamoto, S. (1998, March). *SCR Turnkey Installation Experiences On the SCR Retrofit Project at B.C. Hydro Burrard Thermal Generating Station Units 4, 5 & 6,* Paper presented at the Institute of Clean Air Companies Forum '98, Durham, NC.

Philbrick, J. et al. (1996). *SCR System at Merrimack Unit 2*, Institute of Clean Air Companies Forum.

U.S. Department of Labor (1998). *Geographic Profile of Employment and Unemployment, 1996.* "Table 16. States: Employment status of the experienced civilian labor force by industry, 1996 annual averages."

U.S. Department of Labor (1998, April). *Employment and Earnings.* "Table A-11. Unemployment rates by occupation, industry, and selected demographic characteristics, seasonally adjusted."

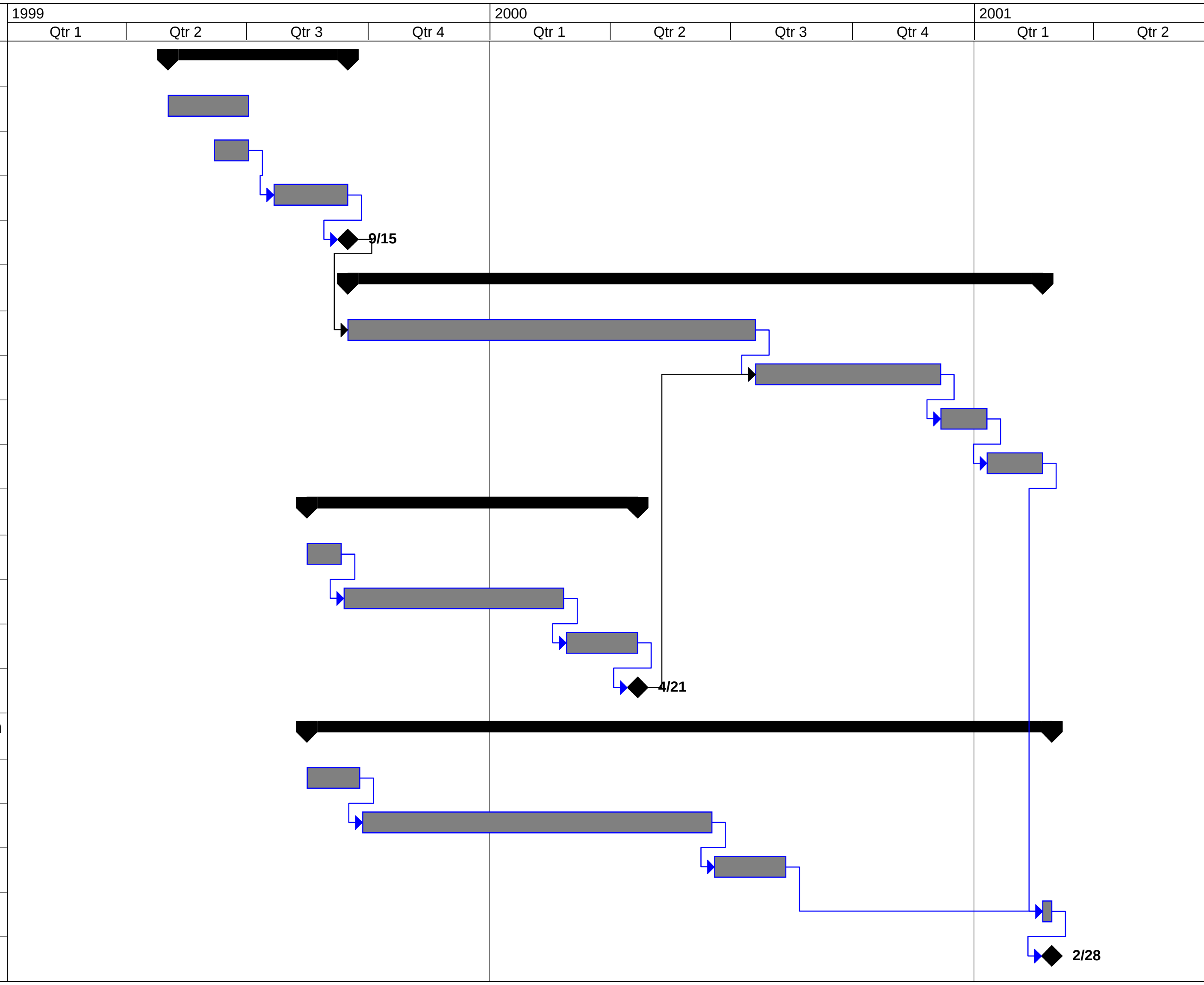
Zamorano, E., et al. (1994). *Case Study in the Retrofit of Selective Catalytic Reduction (SCR) Technologies in the U.S.* Institute of Clean Air Companies Forum.

APPENDIX A

EXHIBIT A-1

Single SCR Retrofit

ID	Task Name
1	**Facility Engineering Review and Award of Contract**
2	Engineering Assessment of Technologies
3	Develop and Send Request for Bids
4	Receive /Review/ Negotiate Bids
5	Award Contract to Technology Provider
6	**Control Technology Installation**
7	Engineering/Fabrication/ Delivery
8	Construction : Pre hook-Up
9	Construction : Control Device Hook-up (Equipment Outage)
10	Control Technology Testing
11	**Construction Permit**
12	Permit Application -Preparation and Submission
13	Construction Permit - State Review and Draft Approval
14	Construction Permit - Public Comment
15	Construction Permit Approval (final)
16	**Title V Operating Permit Modification**
17	Title V Permit Application Preparation and Submission
18	Title V Permit Application - State Review
19	Title V Permit - Public Comment
20	Initial Compliance Stack Testing
21	Receipt of Title V Operating Permit



Date: Mon 8/27/98

Task Milestone Summary

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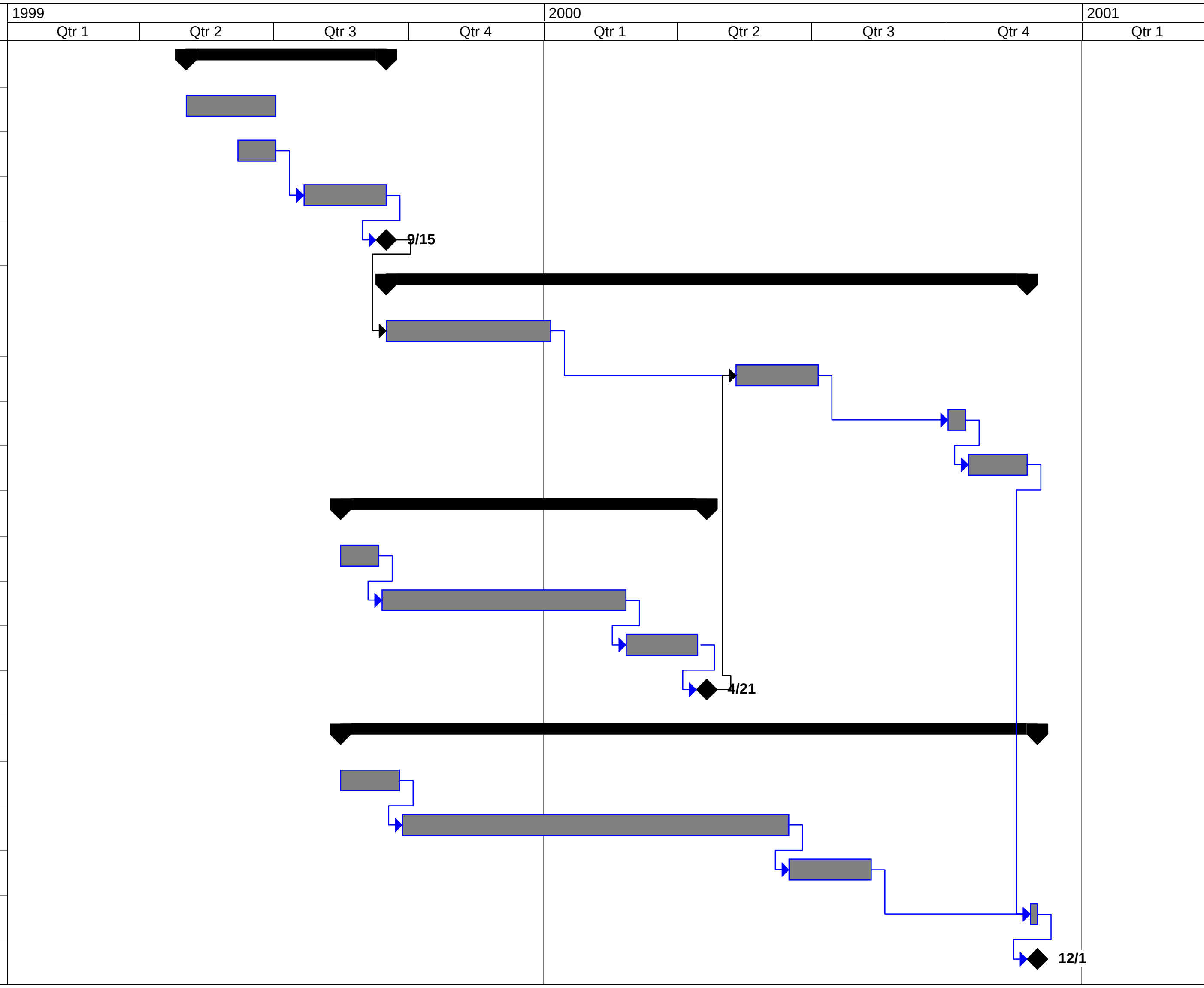
EXHIBIT A-2

Single SNCR Retrofit

ID	Task Name
1	**Facility Engineering Review and Award of Contract**
2	Engineering Assessment of Technologies
3	Develop and Send Request for Bids
4	Receive /Review/ Negotiate Bids
5	Award Contract to Technology Provider
6	**Control Technology Installation**
7	Engineering/Fabrication/ Delivery
8	Construction : Pre Hook-up
9	Construction : Control Device Hook-up (Equipment Outage)
10	Control Technology Testing
11	**Construction Permit**
12	Permit Application -Preparation and Submission
13	Construction Permit - State Review and Draft Approval
14	Construction Permit - Public Comment
15	Construction Permit Approval (final)
16	**Title V Operating Permit Modification**
17	Title V Permit Application Preparation and Submission
18	Title V Permit Application - State Review
19	Title V Permit - Public Comment
20	Initial Compliance Stack Testing
21	Receipt of Title V Operating Permit



Task Milestone Summary

Date: Mon 7/27/98

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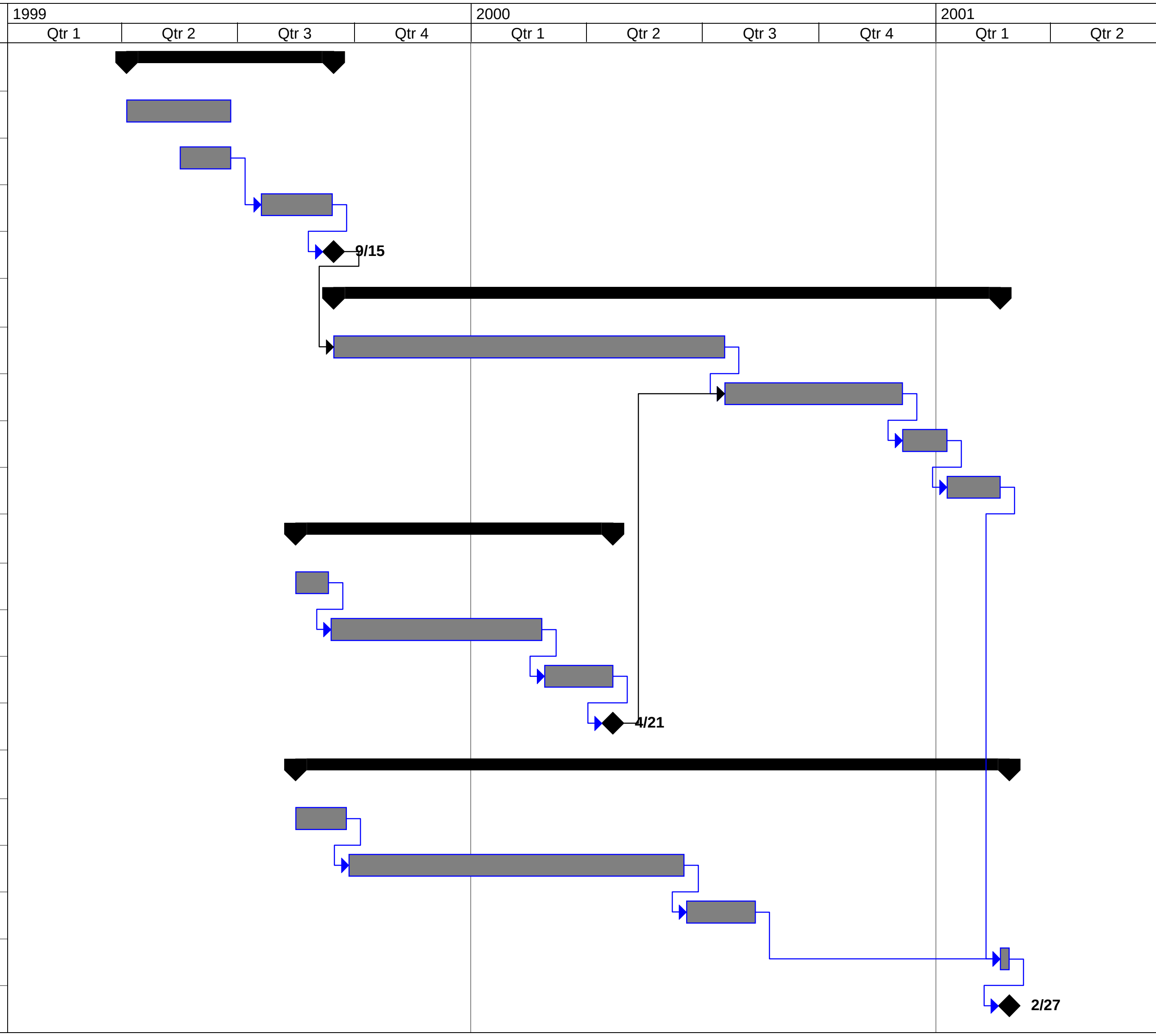
EXHIBIT A-3

Multiple (6) SCR Retrofits - Staggered Installations (Unit 1)

ID	Task Name
1	**Facility Engineering Review and Award of Contract (All Units)**
2	Engineering Assessment of Technologies
3	Develop and Send Request for Bids
4	Receive /Review/ Negotiate Bids
5	Award Contract to Technology Provider
6	**Control Technology Installation (Unit 1)**
7	Engineering/Fabrication/ Delivery
8	Construction : Pre Hook-Up
9	Construction : Control Device Hook-up (Equipment Outage)
10	Control Technology Testing
11	**Construction Permit (Unit 1)**
12	Permit Application -Preparation and Submission
13	Construction Permit - State Review and Draft Approval
14	Construction Permit - Public Comment
15	Construction Permit Approval (final)
16	**Title V Operating Permit Modification (Unit 1)**
17	Title V Permit Application Preparation and Submission
18	Title V Permit Application - State Review
19	Title V Permit - Public Comment
20	Initial Compliance Stack Testing
21	Title V Operating Permit Modification



Task Milestone Summary

Date: Sun 7/26/98

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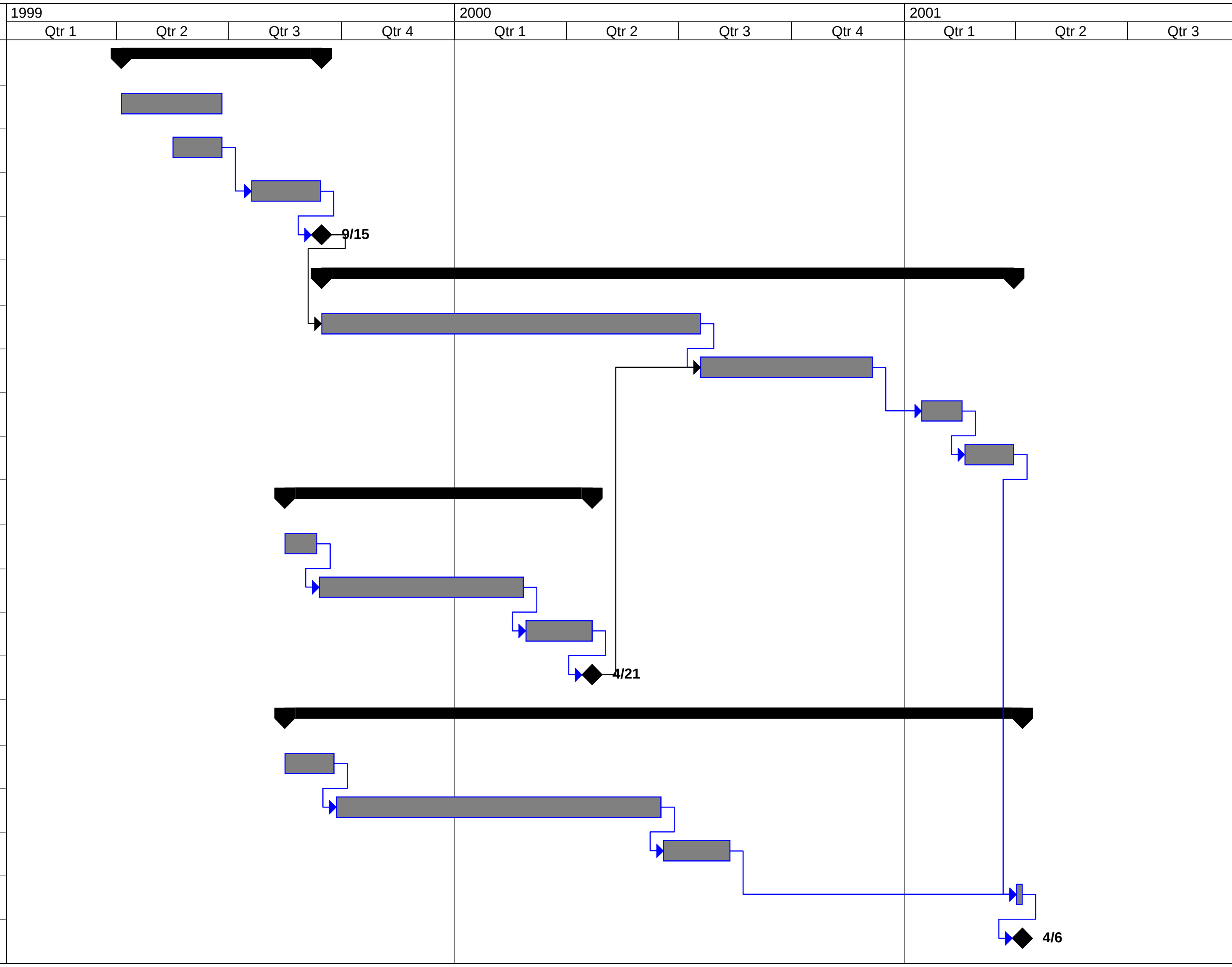
Multiple (6) SCR Retrofits - Staggered Installations (Unit 2)

ID	Task Name
1	**Facility Engineering Review and Award of Contract (All Units)**
2	Engineering Assessment of Technologies
3	Develop and Send Request for Bids
4	Receive /Review/ Negotiate Bids
5	Award Contract to Technology Provider
6	**Control Technology Installation (Unit 2)**
7	Engineering/Fabrication/ Delivery
8	Construction - Pre Hook-Up
9	Construction : Control Device Hook-up (Equipment Outage)
10	Control Technology Testing
11	**Construction Permit (Unit 2)**
12	Permit Application -Preparation and Submission
13	Construction Permit - State Review and Draft Approval
14	Construction Permit - Public Comment
15	Construction Permit Approval (final)
16	**Title V Operating Permit Modification (Unit 2)**
17	Title V Permit Application Preparation and Submission
18	Title V Permit Application - State Review
19	Title V Permit - Public Comment
20	Initial Compliance Stack Testing
21	Title V Operating Permit Modification



Task Milestone Summary

Date: Sun 7/26/98

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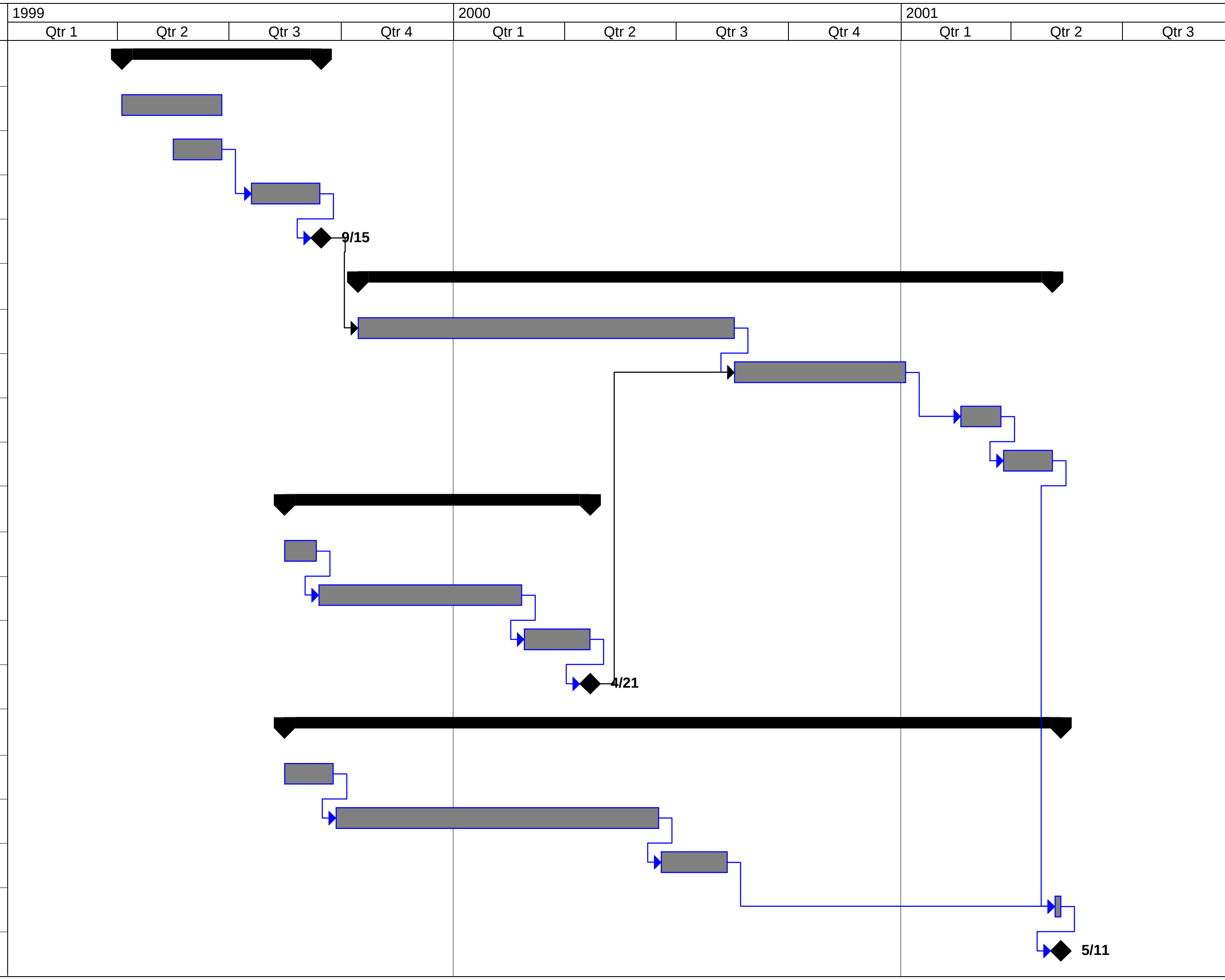
Multiple (6) SCR Retrofits - Staggered Installations (Unit 3)

ID	Task Name
1	**Facility Engineering Review and Award of Contract (All Units)**
2	Engineering Assessment of Technologies
3	Develop and Send Request for Bids
4	Receive /Review/ Negotiate Bids
5	Award Contract to Technology Provider
6	**Control Technology Installation (Unit 3)**
7	Engineering/Fabrication/ Delivery
8	Construction : Pre Hook-Up
9	Construction : Control Device Hook-up (Equipment Outage)
10	Control Technology Testing
11	**Construction Permit (Unit 3)**
12	Permit Application -Preparation and Submission
13	Construction Permit - State Review and Draft Approval
14	Construction Permit - Public Comment
15	Construction Permit Approval (final)
16	**Title V Operating Permit Modification (Unit 3)**
17	Title V Permit Application Preparation and Submission
18	Title V Permit Application - State Review
19	Title V Permit - Public Comment
20	Initial Compliance Stack Testing
21	Title V Operating Permit Modification



Task | Milestone | Summary

Date: Sun 7/26/98

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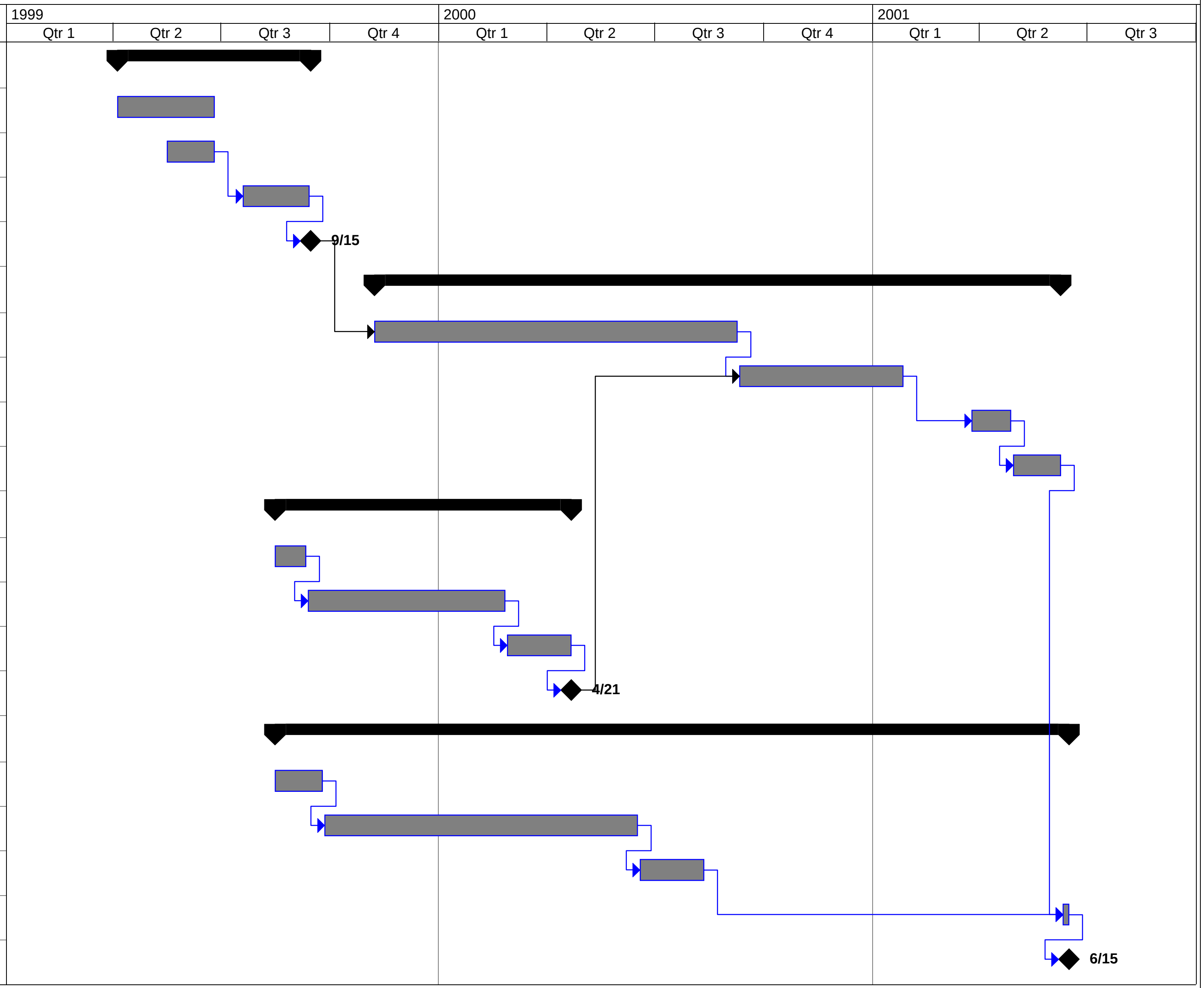
Multiple (6) SCR Retrofits - Staggered Installations (Unit 4)

ID	Task Name
1	**Facility Engineering Review and Award of Contract (All Units)**
2	Engineering Assessment of Technologies
3	Develop and Send Request for Bids
4	Receive /Review/ Negotiate Bids
5	Award Contract to Technology Provider
6	**Control Technology Installation (Unit 4)**
7	Engineering/Fabrication/ Delivery
8	Construction - Pre Hook-Up
9	Construction : Control Device Hook-up (Equipment Outage)
10	Control Technology Testing
11	**Construction Permit (Unit 4)**
12	Permit Application -Preparation and Submission
13	Construction Permit - State Review and Draft Approval
14	Construction Permit - Public Comment
15	Construction Permit Approval (final)
16	**Title V Operating Permit Modification (Unit 4)**
17	Title V Permit Application Preparation and Submission
18	Title V Permit Application - State Review
19	Title V Permit - Public Comment
20	Initial Compliance Stack Testing
21	Title V Operating Permit Modification



Task Milestone Summary

Date: Sun 7/26/98

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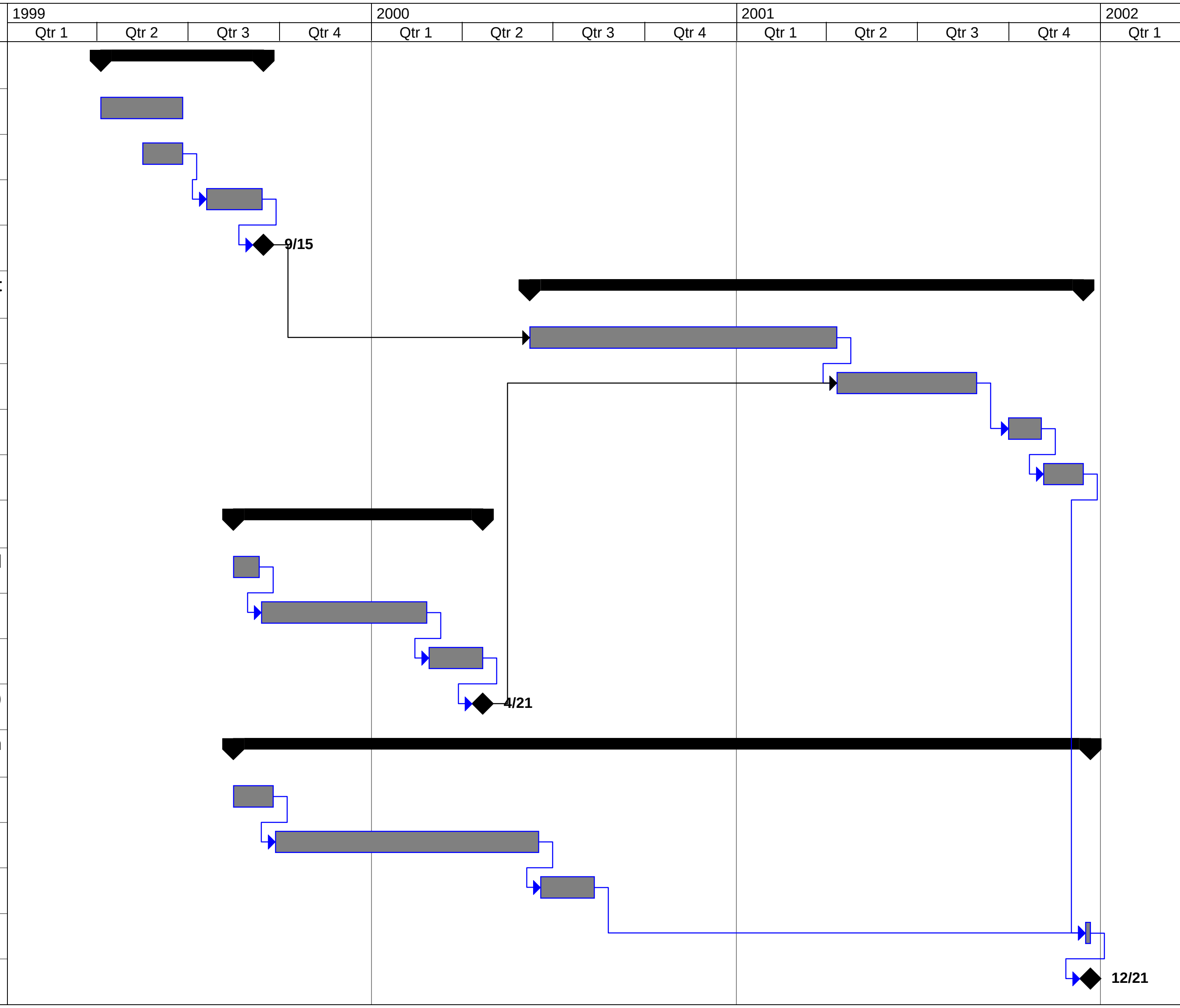
Multiple (6) SCR Retrofits- Staggered Installations (Unit 5)

ID	Task Name
1	**Facility Engineering Review and Award of Contract (All Units)**
2	Engineering Assessment of Technologies
3	Develop and Send Request for Bids
4	Receive /Review/ Negotiate Bids
5	Award Contract to Technology Provider
6	**Control Technology Installation (Unit 5)**
7	Engineering/Fabrication/ Delivery
8	Construction - Pre Hook-Up
9	Construction : Control Device Hook-up (Equipment Outage)
10	Control Technology Testing
11	**Construction Permit (Unit 5)**
12	Permit Application -Preparation and Submission
13	Construction Permit - State Review and Draft Approval
14	Construction Permit - Public Comment
15	Construction Permit Approval (final)
16	**Title V Operating Permit Modification (Unit 5)**
17	Title V Permit Application Preparation and Submission
18	Title V Permit Application - State Review
19	Title V Permit - Public Comment
20	Initial Compliance Stack Testing
21	Title V Operating Permit Modification



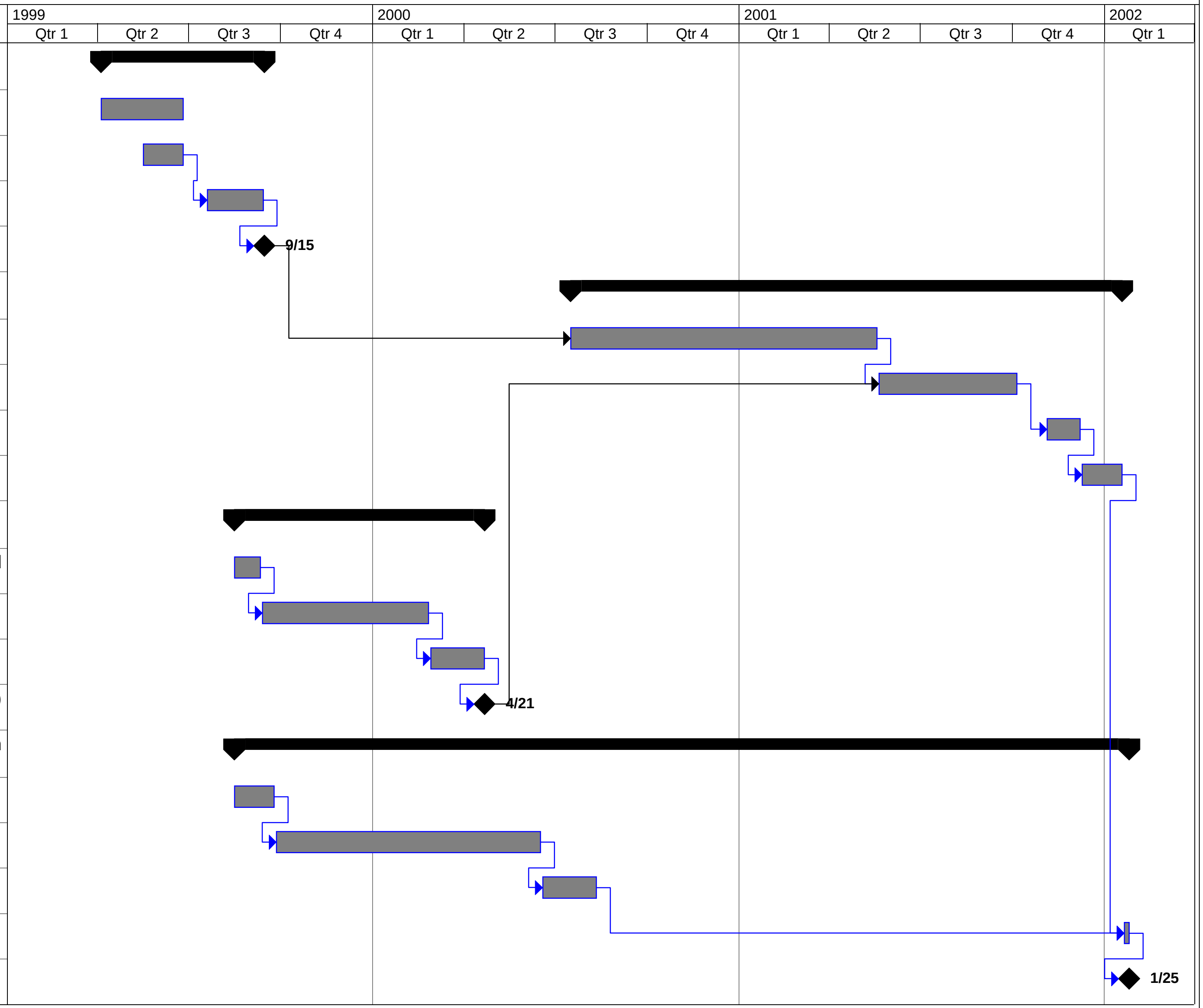
Date: Sun 7/26/98

Task | Milestone | Summary

- DRAFT-

Multiple (6) SCR Retrofits - Staggered Installations (Unit 6)

ID	Task Name
1	**Facility Engineering Review and Award of Contract (All Units)**
2	Engineering Assessment of Technologies
3	Develop and Send Request for Bids
4	Receive /Review/ Negotiate Bids
5	Award Contract to Technology Provider
6	**Control Technology Installation (Unit 6)**
7	Engineering/Fabrication/ Delivery
8	Construction : Pre Hook-Up
9	Construction : Control Device Hook-up (Equipment Outage)
10	Control Technology Testing
11	**Construction Permit (Unit 6)**
12	Permit Application -Preparation and Submission
13	Construction Permit - State Review and Draft Approval
14	Construction Permit - Public Comment
15	Construction Permit Approval (final)
16	**Title V Operating Permit Modification (Unit 6)**
17	Title V Permit Application Preparation and Submission
18	Title V Permit Application - State Review
19	Title V Permit - Public Comment
20	Initial Compliance Stack Testing
21	Title V Operating Permit Modification



Task | Milestone | Summary

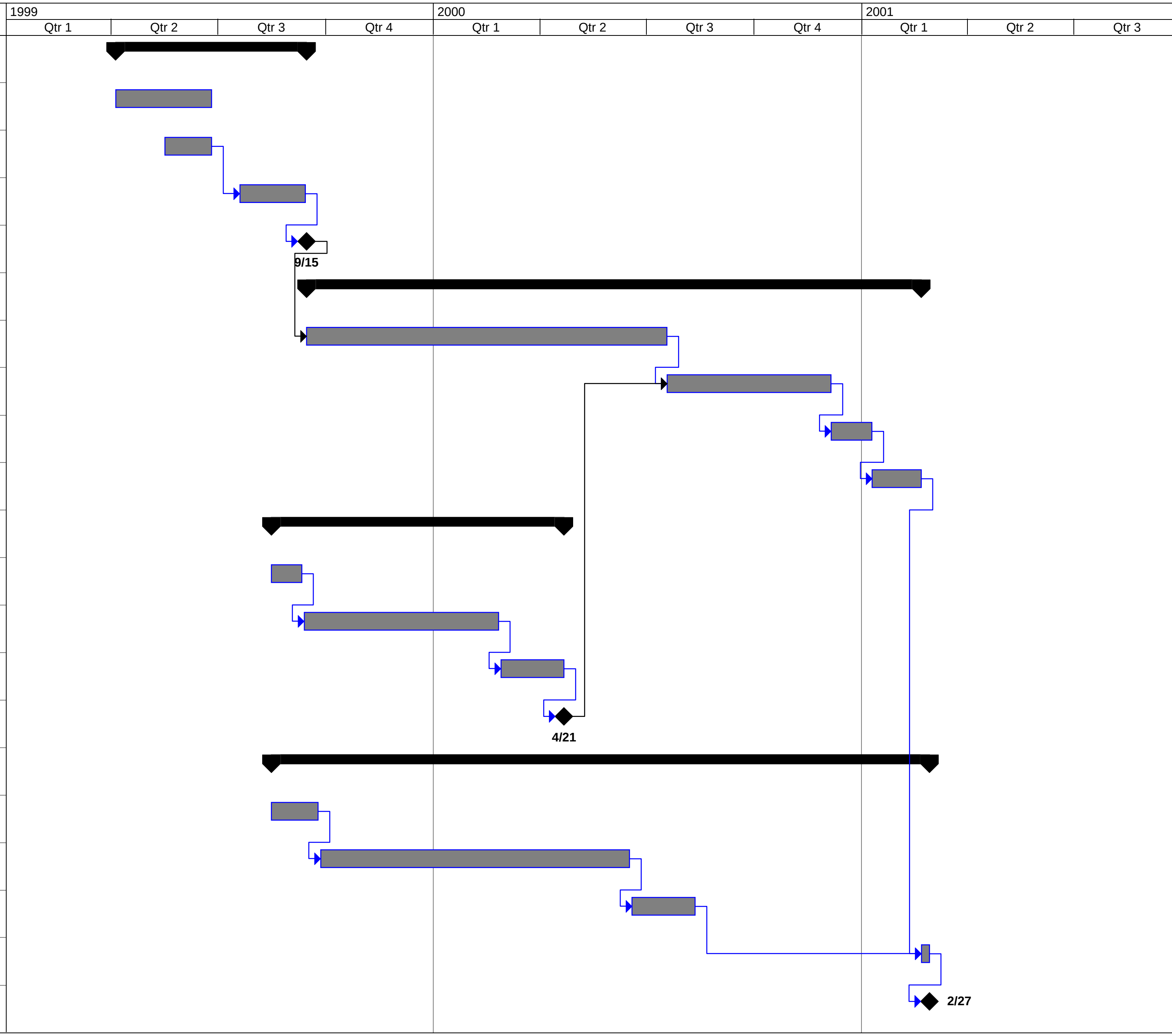
Date: Sun 7/26/98

- DRAFT-

EXHIBIT A-4

Multiple (6) SCR Retrofits - Simultaneous Installations (Units 1 & 2)

ID	Task Name
1	**Facility Engineering Review and Award of Contract (All Units)**
2	Engineering Assessment of Technologies
3	Develop and Send Request for Bids
4	Receive /Review/ Negotiate Bids
5	Award Contract to Technology Provider
6	**Control Technology Installation (Units 1 & 2)**
7	Engineering/Fabrication/ Delivery
8	Construction - Pre Hook-Up
9	Construction : Control Device Hook-up (Equipment Outage)
10	Control Technology Testing
11	**Construction Permit (Units 1 & 2)**
12	Permit Application -Preparation and Submission
13	Construction Permit - State Review and Draft Approval
14	Construction Permit - Public Comment
15	Construction Permit Approval (final)
16	**Title V Operating Permit Modification (Units 1 & 2)**
17	Title V Permit Application Preparation and Submission
18	Title V Permit Application - State Review
19	Title V Permit - Public Comment
20	Initial Compliance Stack Testing
21	Title V Operating Permit Modification



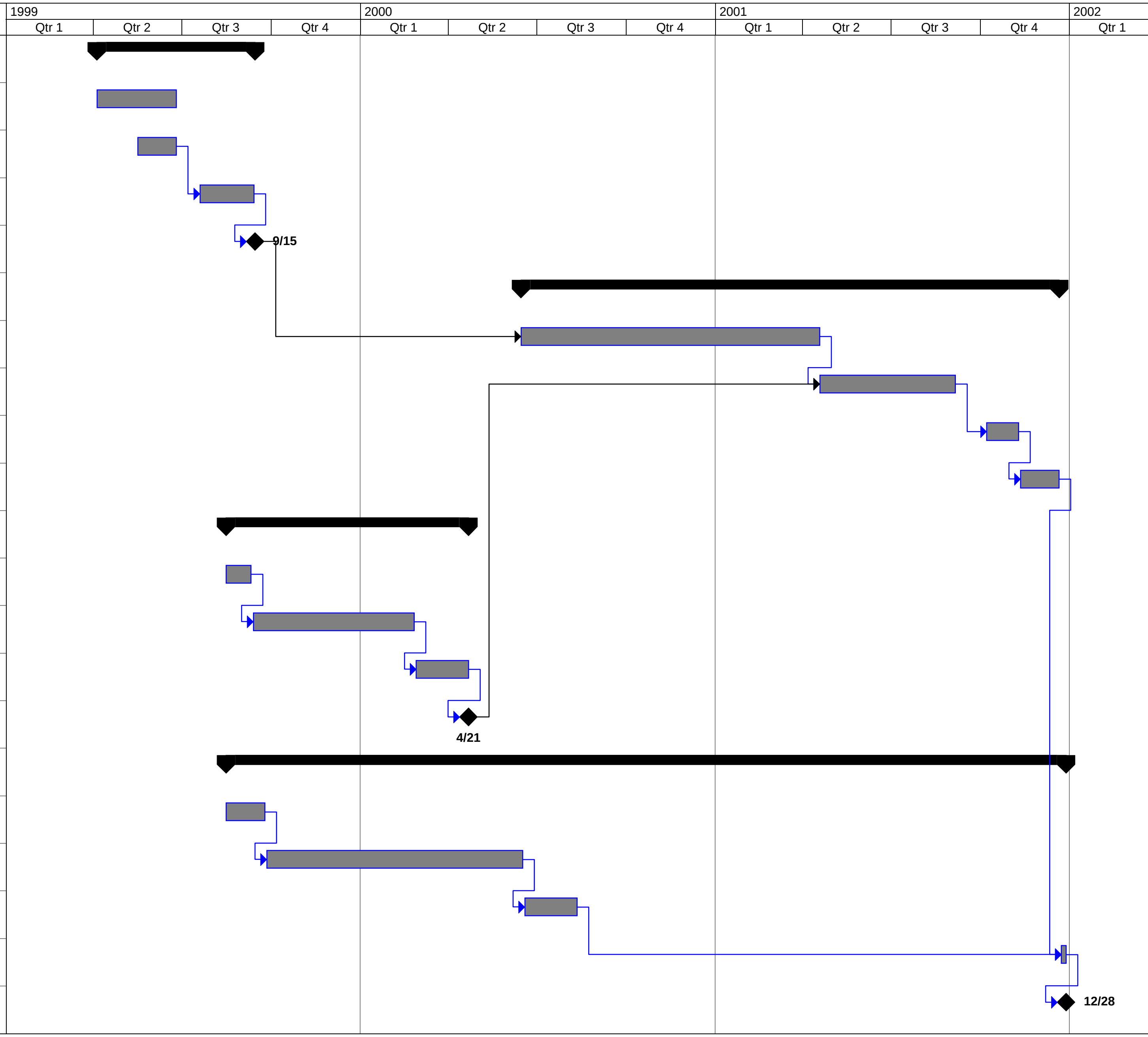
Date: Sun 7/26/98

Task Milestone Summary

- DRAFT-

Multiple (6) SCR Retrofits - Simultaneous Installations (Units 3 & 4)

ID	Task Name
1	**Facility Engineering Review and Award of Contract (All Units)**
2	Engineering Assessment of Technologies
3	Develop and Send Request for Bids
4	Receive /Review/ Negotiate Bids
5	Award Contract to Technology Provider
6	**Control Technology Installation (Units 3 & 4)**
7	Engineering/Fabrication/ Delivery
8	Construction - Pre Hook-Up
9	Construction : Control Device Hook-up (Equipment Outage)
10	Control Technology Testing
11	**Construction Permit (Units 3 & 4)**
12	Permit Application -Preparation and Submission
13	Construction Permit - State Review and Draft Approval
14	Construction Permit - Public Comment
15	Construction Permit Approval (final)
16	**Title V Operating Permit Modification (Units 3 & 4)**
17	Title V Permit Application Preparation and Submission
18	Title V Permit Application - State Review
19	Title V Permit - Public Comment
20	Initial Compliance Stack Testing
21	Title V Operating Permit Modification



Task | Milestone | Summary

Date: Sun 7/26/98

- DRAFT -

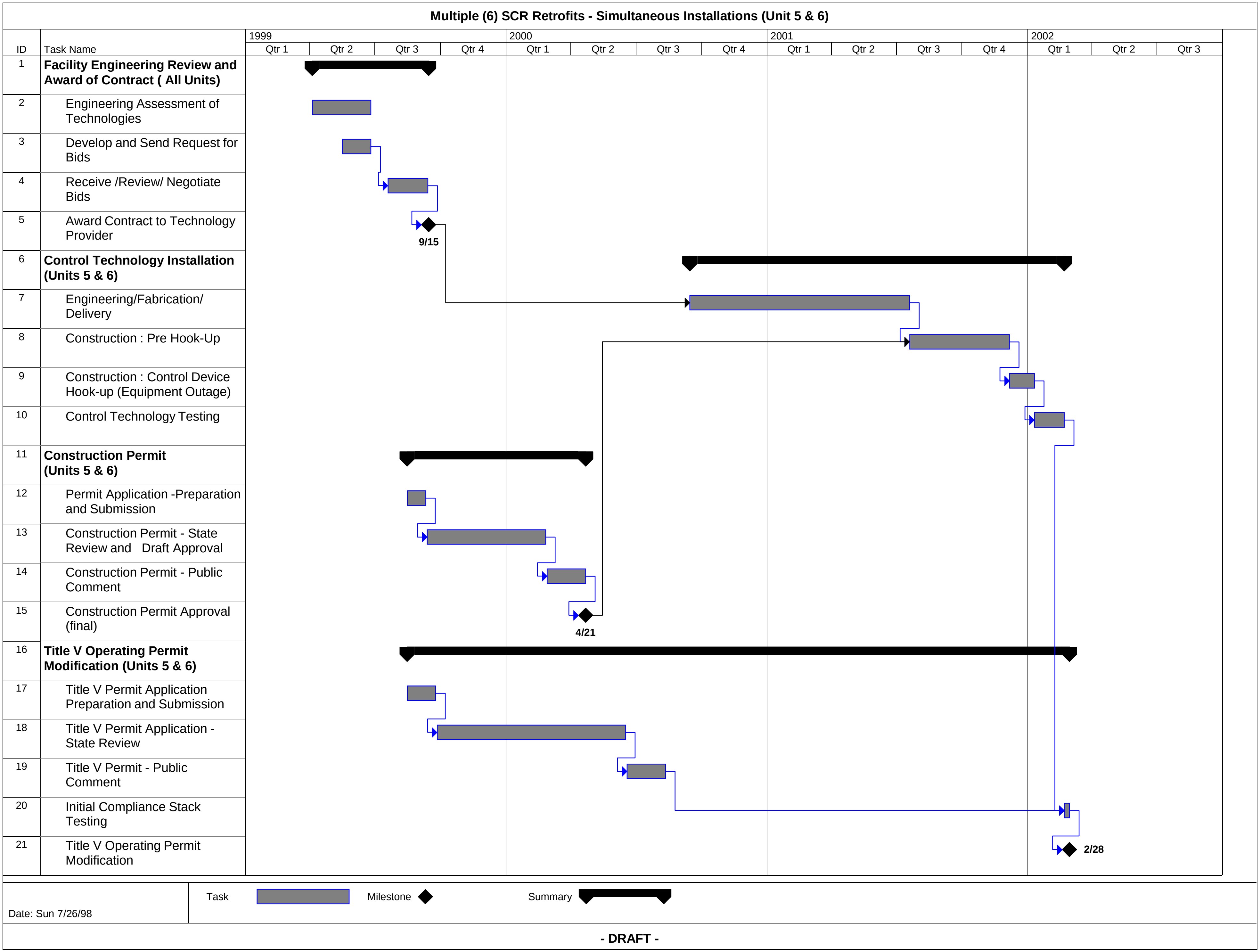
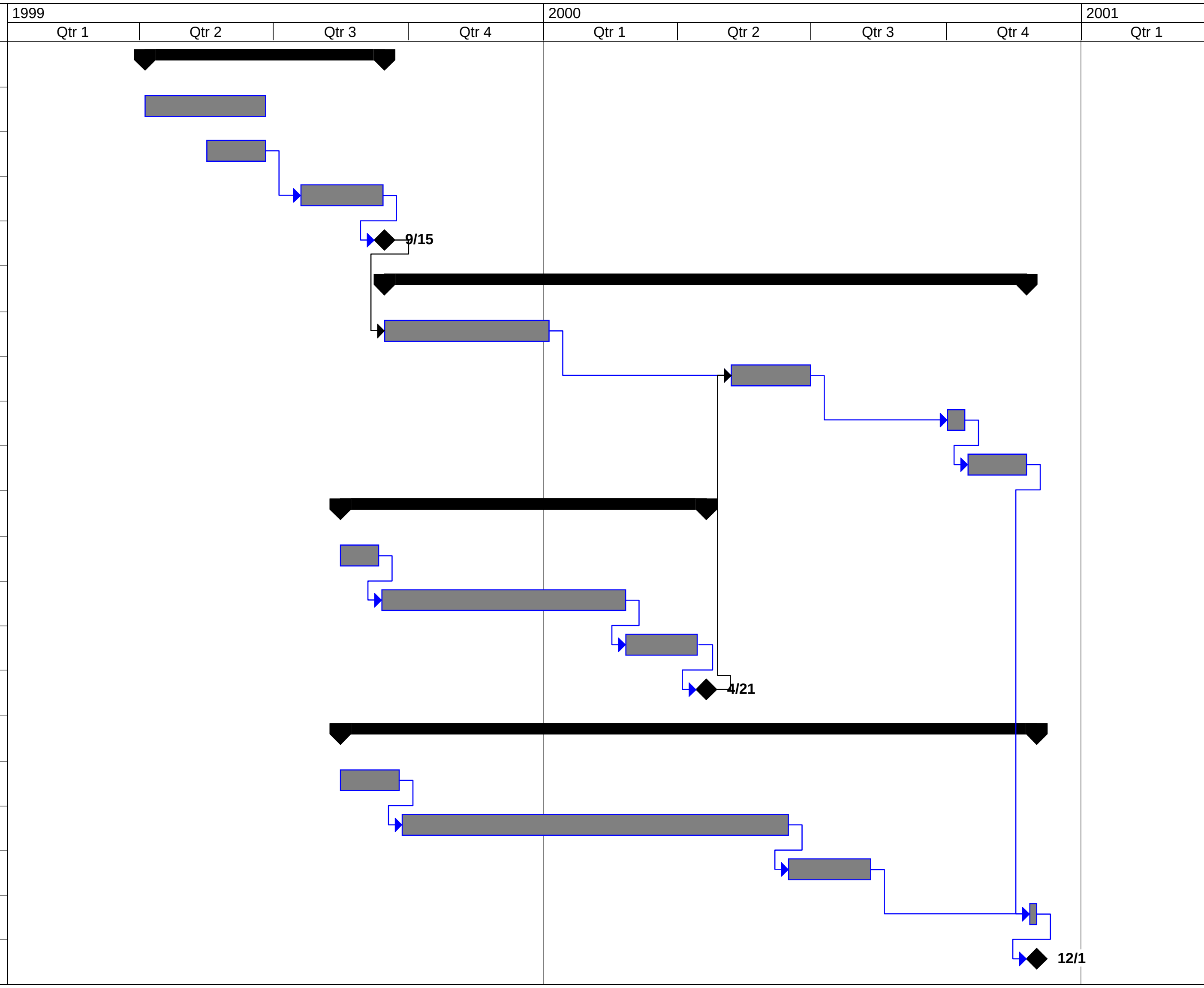

Multiple (6) SCR Retrofits - Simultaneous Installations (Unit 5 & 6)
ID
Task Name
1999
2000
2001
2002
Qtr 1
Qtr 2
Qtr 3
Qtr 4
1 Facility Engineering Review and Award of Contract (All Units)
2 Engineering Assessment of Technologies
3 Develop and Send Request for Bids
4 Receive /Review/ Negotiate Bids
5 Award Contract to Technology Provider
9/15
6 Control Technology Installation (Units 5 & 6)
7 Engineering/Fabrication/ Delivery
8 Construction : Pre Hook-Up
9 Construction : Control Device Hook-up (Equipment Outage)
10 Control Technology Testing
11 Construction Permit (Units 5 & 6)
12 Permit Application -Preparation and Submission
13 Construction Permit - State Review and Draft Approval
14 Construction Permit - Public Comment
15 Construction Permit Approval (final)
4/21
16 Title V Operating Permit Modification (Units 5 & 6)
17 Title V Permit Application Preparation and Submission
18 Title V Permit Application - State Review
19 Title V Permit - Public Comment
20 Initial Compliance Stack Testing
21 Title V Operating Permit Modification
2/28
Task
Milestone
Summary
Date: Sun 7/26/98
- DRAFT -

EXHIBIT A-5

Multiple (10) SNCR Retrofits - Staggered Installations (Unit 1)

ID	Task Name
1	**Facility Engineering Review and Award of Contract (All Units)**
2	Engineering Assessment of Technologies
3	Develop and Send Request for Bids
4	Receive /Review/ Negotiate Bids
5	Award Contract to Technology Provider
6	**Control Technology Installation (Unit 1)**
7	Engineering/Fabrication/ Delivery
8	Construction : Pre Hook-up
9	Construction : Control Device Hook-up (Equipment Outage)
10	Control Technology Testing
11	**Construction Permit (Unit 1)**
12	Permit Application -Preparation and Submission
13	Construction Permit - State Review and Draft Approval
14	Construction Permit - Public Comment
15	Construction Permit Approval (final)
16	**Title V Operating Permit Modification (Unit 1)**
17	Title V Permit Application Preparation and Submission
18	Title V Permit Application - State Review
19	Title V Permit - Public Comment
20	Initial Compliance Stack Testing
21	Title V Operating Permit Modification



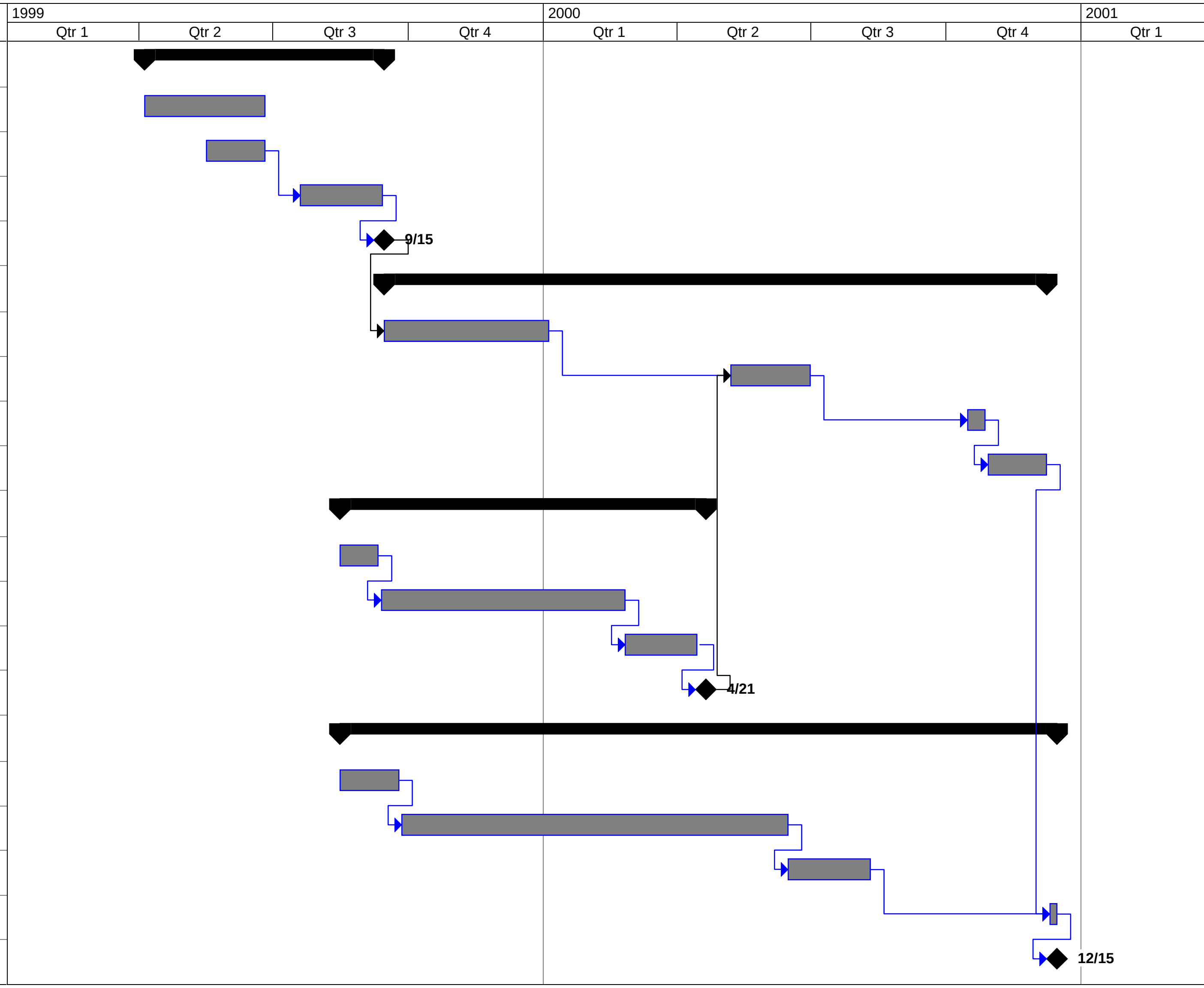
Task Milestone Summary

Date: Mon 7/27/98

- DRAFT-

Multiple (10) SNCR Retrofits - Staggered Installations (Unit 2)

ID	Task Name
1	**Facility Engineering Review and Award of Contract (All Units)**
2	Engineering Assessment of Technologies
3	Develop and Send Request for Bids
4	Receive /Review/ Negotiate Bids
5	Award Contract to Technology Provider
6	**Control Technology Installation (Unit 2)**
7	Engineering/Fabrication/ Delivery
8	Construction : Pre Hook-up
9	Construction : Control Device Hook-up (Equipment Outage)
10	Control Technology Testing
11	**Construction Permit (Unit 2)**
12	Permit Application -Preparation and Submission
13	Construction Permit - State Review and Draft Approval
14	Construction Permit - Public Comment
15	Construction Permit Approval (final)
16	**Title V Operating Permit Modification (Unit 2)**
17	Title V Permit Application Preparation and Submission
18	Title V Permit Application - State Review
19	Title V Permit - Public Comment
20	Initial Compliance Stack Testing
21	Title V Operating Permit Modification



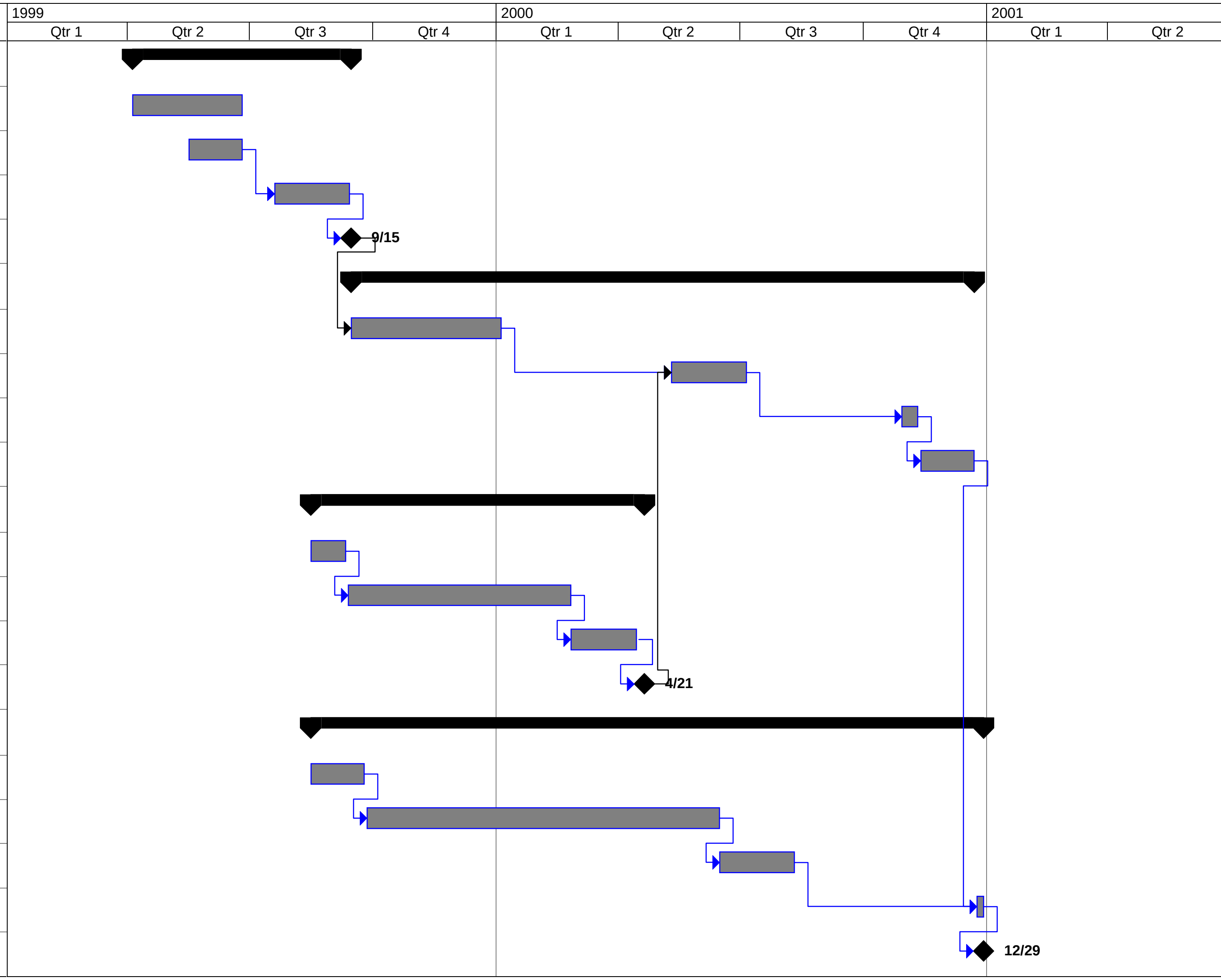
Task Milestone Summary

Date: Mon 7/27/98

- DRAFT-

Multiple (10) SNCR Retrofits - Staggered Installations (Unit 3)

ID	Task Name
1	**Facility Engineering Review and Award of Contract (All Units)**
2	Engineering Assessment of Technologies
3	Develop and Send Request for Bids
4	Receive /Review/ Negotiate Bids
5	Award Contract to Technology Provider
6	**Control Technology Installation (Unit 3)**
7	Engineering/Fabrication/ Delivery
8	Construction : Pre Hook-up
9	Construction : Control Device Hook-up (Equipment Outage)
10	Control Technology Testing
11	**Construction Permit (Unit 3)**
12	Permit Application -Preparation and Submission
13	Construction Permit - State Review and Draft Approval
14	Construction Permit - Public Comment
15	Construction Permit Approval (final)
16	**Title V Operating Permit Modification (Unit 3)**
17	Title V Permit Application Preparation and Submission
18	Title V Permit Application - State Review
19	Title V Permit - Public Comment
20	Initial Compliance Stack Testing
21	Title V Operating Permit Modification



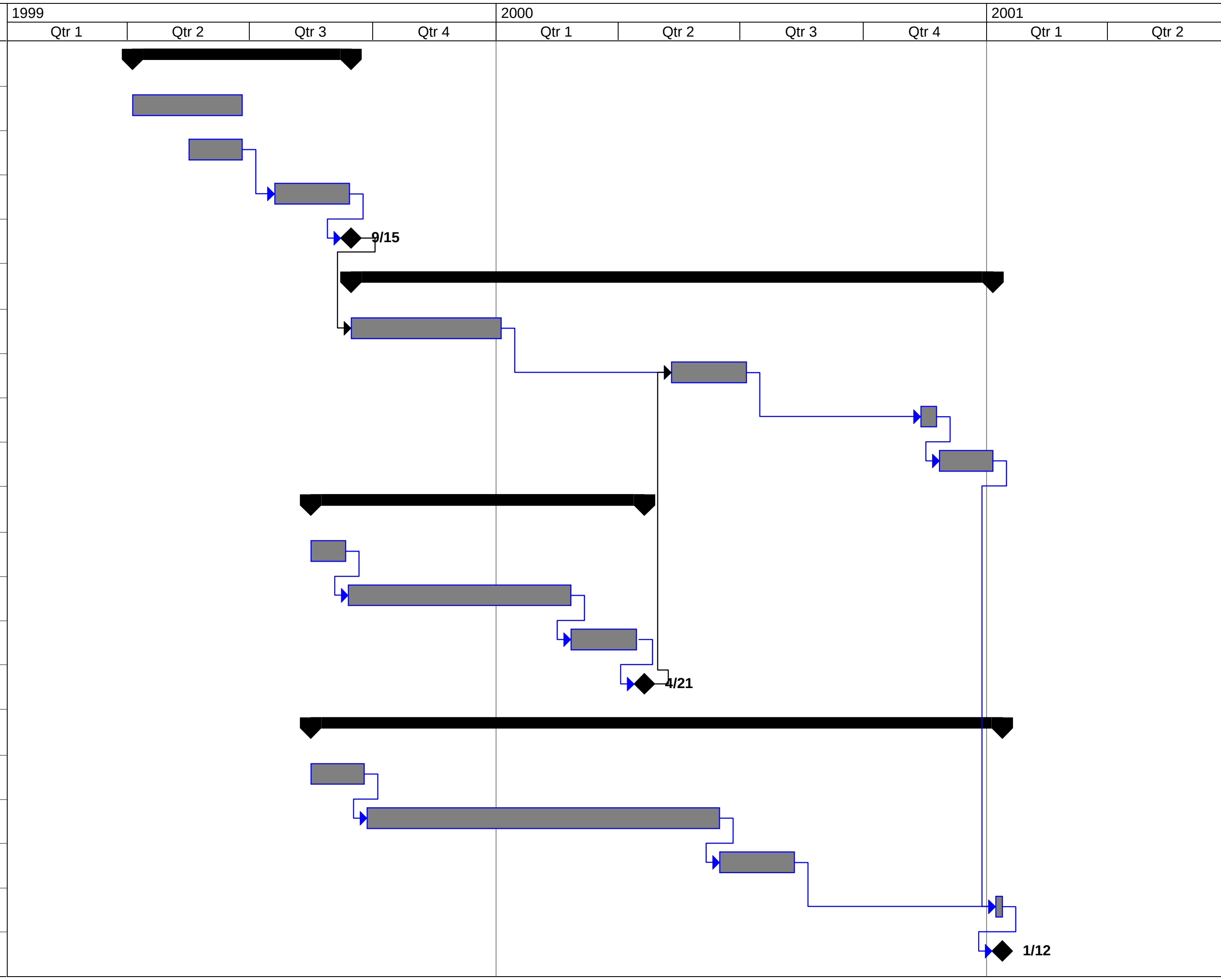
Task | Milestone | Summary

Date: Mon 7/27/98

- DRAFT-

Multiple (10) SNCR Retrofits - Staggered Installations (Unit 4)

ID	Task Name
1	**Facility Engineering Review and Award of Contract (All Units)**
2	Engineering Assessment of Technologies
3	Develop and Send Request for Bids
4	Receive /Review/ Negotiate Bids
5	Award Contract to Technology Provider
6	**Control Technology Installation (Unit 4)**
7	Engineering/Fabrication/ Delivery
8	Construction : Pre Hook-up
9	Construction : Control Device Hook-up (Equipment Outage)
10	Control Technology Testing
11	**Construction Permit (Unit 4)**
12	Permit Application -Preparation and Submission
13	Construction Permit - State Review and Draft Approval
14	Construction Permit - Public Comment
15	Construction Permit Approval (final)
16	**Title V Operating Permit Modification (Unit 4)**
17	Title V Permit Application Preparation and Submission
18	Title V Permit Application - State Review
19	Title V Permit - Public Comment
20	Initial Compliance Stack Testing
21	Title V Operating Permit Modification



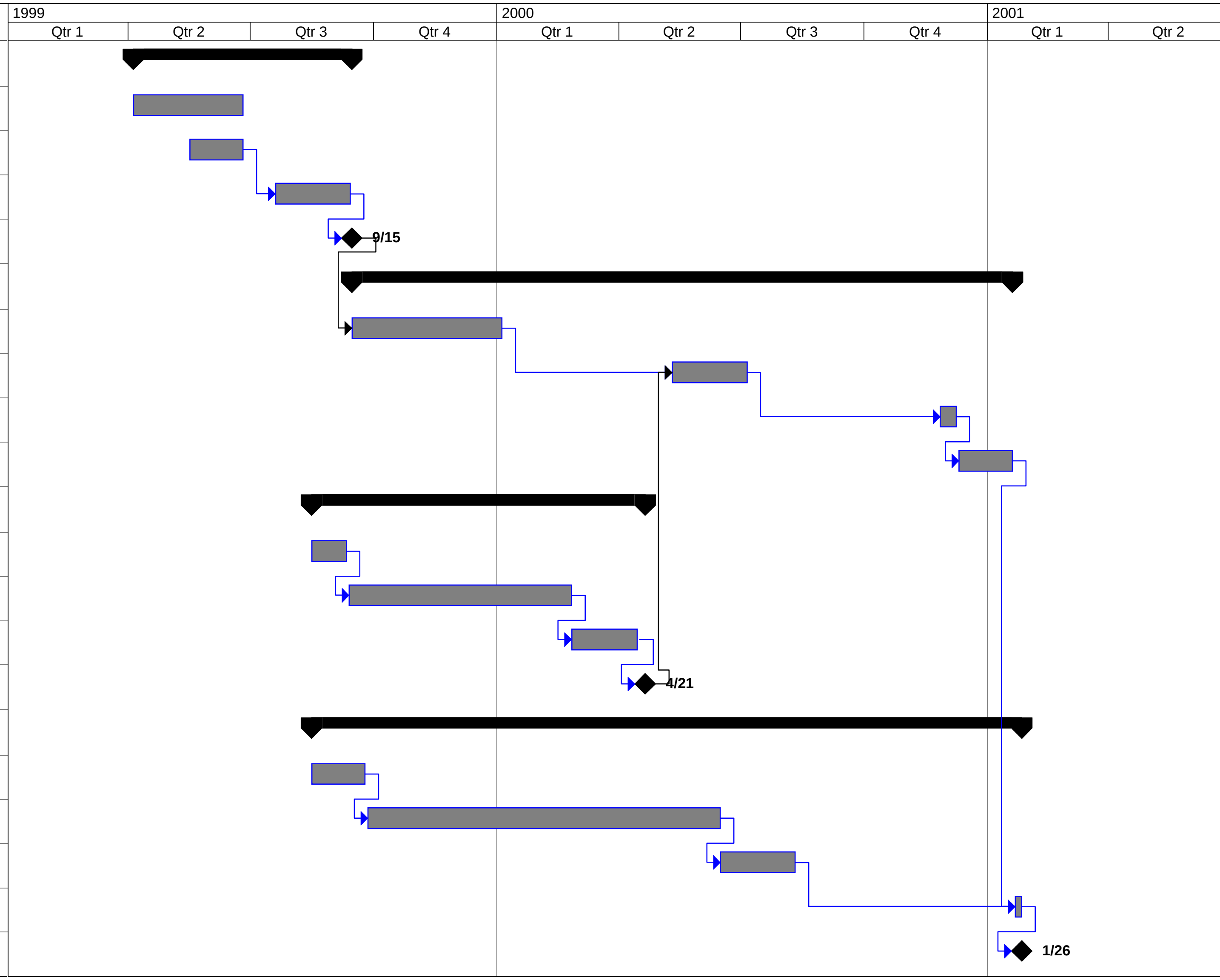
Task Milestone Summary

Date: Mon 7/27/98

- DRAFT-

Multiple (10) SNCR Retrofits - Staggered Installations (Unit 5)

ID	Task Name
1	**Facility Engineering Review and Award of Contract (All Units)**
2	Engineering Assessment of Technologies
3	Develop and Send Request for Bids
4	Receive /Review/ Negotiate Bids
5	Award Contract to Technology Provider
6	**Control Technology Installation (Unit 5)**
7	Engineering/Fabrication/ Delivery
8	Construction : Pre Hook-up
9	Construction : Control Device Hook-up (Equipment Outage)
10	Control Technology Testing
11	**Construction Permit (Unit 5)**
12	Permit Application -Preparation and Submission
13	Construction Permit - State Review and Draft Approval
14	Construction Permit - Public Comment
15	Construction Permit Approval (final)
16	**Title V Operating Permit Modification (Unit 5)**
17	Title V Permit Application Preparation and Submission
18	Title V Permit Application - State Review
19	Title V Permit - Public Comment
20	Initial Compliance Stack Testing
21	Title V Operating Permit Modification



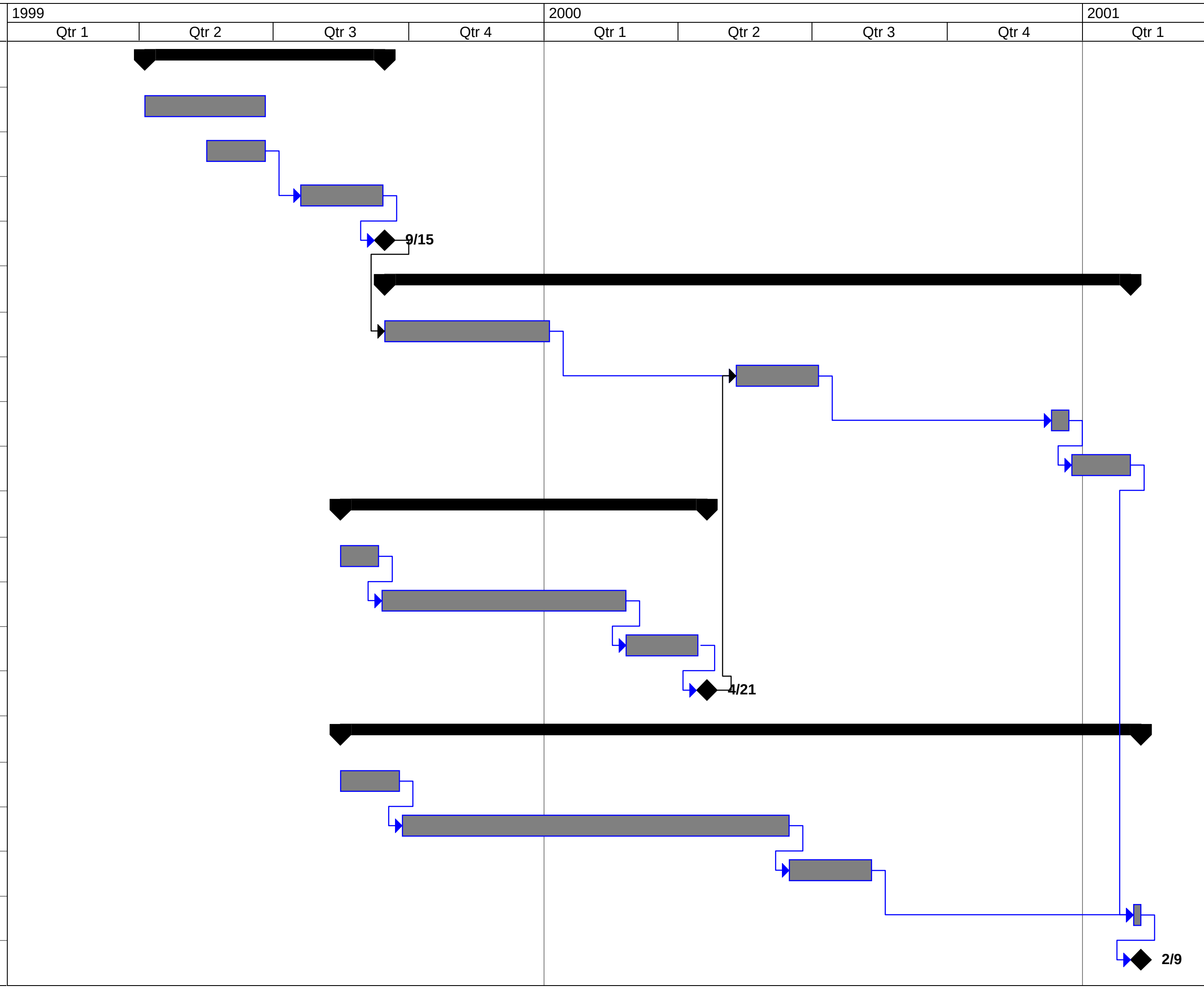
Task　Milestone　Summary

Date: Mon 7/27/98

- DRAFT-

Multiple (10) SNCR Retrofits - Staggered Installations (Unit 6)

ID	Task Name
1	**Facility Engineering Review and Award of Contract (All Units)**
2	Engineering Assessment of Technologies
3	Develop and Send Request for Bids
4	Receive /Review/ Negotiate Bids
5	Award Contract to Technology Provider
6	**Control Technology Installation (Unit 6)**
7	Engineering/Fabrication/ Delivery
8	Construction : Pre Hook-up
9	Construction : Control Device Hook-up (Equipment Outage)
10	Control Technology Testing
11	**Construction Permit (Unit6)**
12	Permit Application -Preparation and Submission
13	Construction Permit - State Review and Draft Approval
14	Construction Permit - Public Comment
15	Construction Permit Approval (final)
16	**Title V Operating Permit Modification (Unit 6)**
17	Title V Permit Application Preparation and Submission
18	Title V Permit Application - State Review
19	Title V Permit - Public Comment
20	Initial Compliance Stack Testing
21	Title V Operating Permit Modification



Task | Milestone | Summary

Date: Mon 7/27/98

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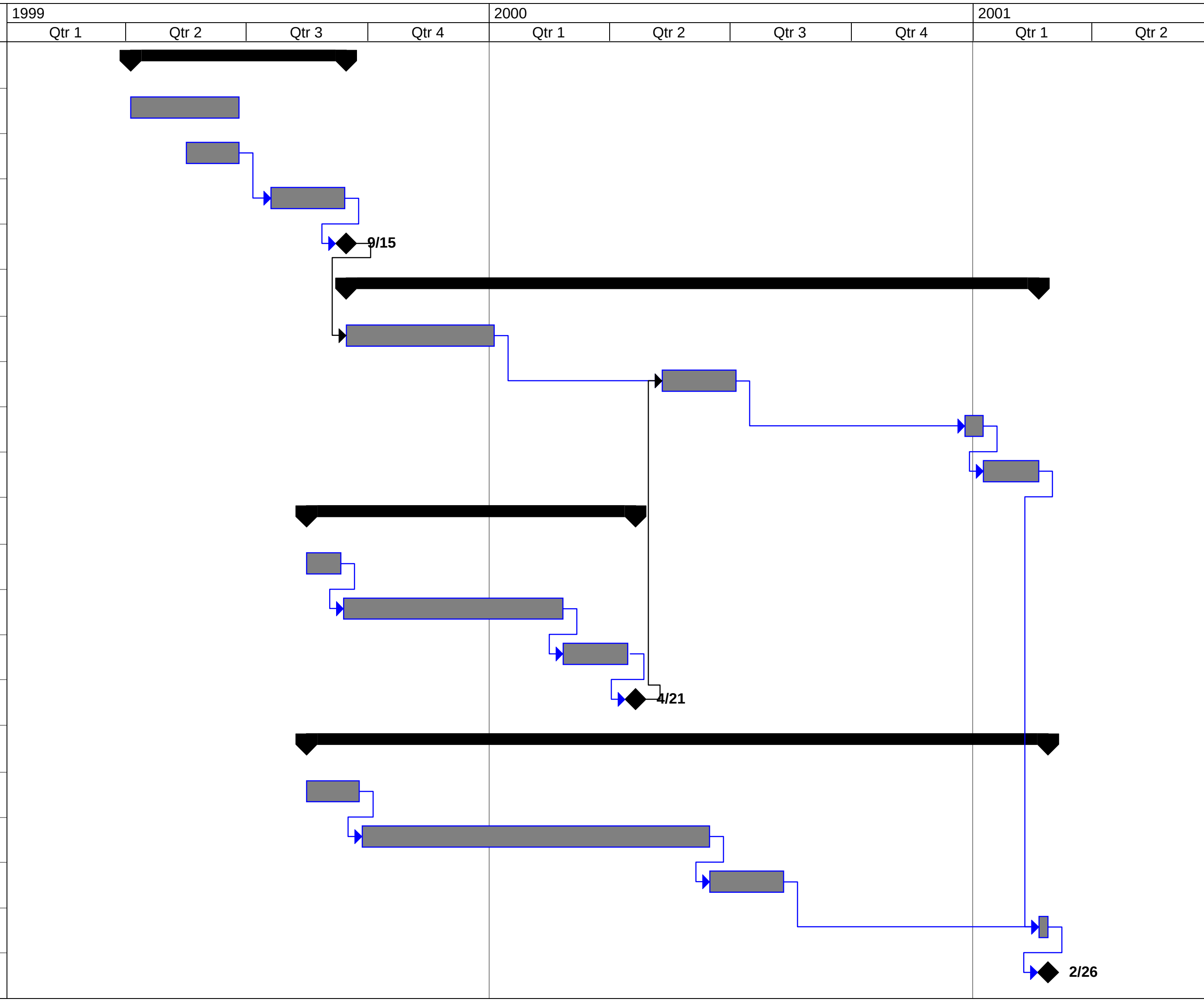
Multiple (10) SNCR Retrofits - Staggered Installations (Unit 7)

ID	Task Name
1	**Facility Engineering Review and Award of Contract (All Units)**
2	Engineering Assessment of Technologies
3	Develop and Send Request for Bids
4	Receive /Review/ Negotiate Bids
5	Award Contract to Technology Provider
6	**Control Technology Installation (Unit 7)**
7	Engineering/Fabrication/ Delivery
8	Construction : Pre Hook-up
9	Construction : Control Device Hook-up (Equipment Outage)
10	Control Technology Testing
11	**Construction Permit (Unit 7)**
12	Permit Application -Preparation and Submission
13	Construction Permit - State Review and Draft Approval
14	Construction Permit - Public Comment
15	Construction Permit Approval (final)
16	**Title V Operating Permit Modification (Unit 7)**
17	Title V Permit Application Preparation and Submission
18	Title V Permit Application - State Review
19	Title V Permit - Public Comment
20	Initial Compliance Stack Testing
21	Title V Operating Permit Modification



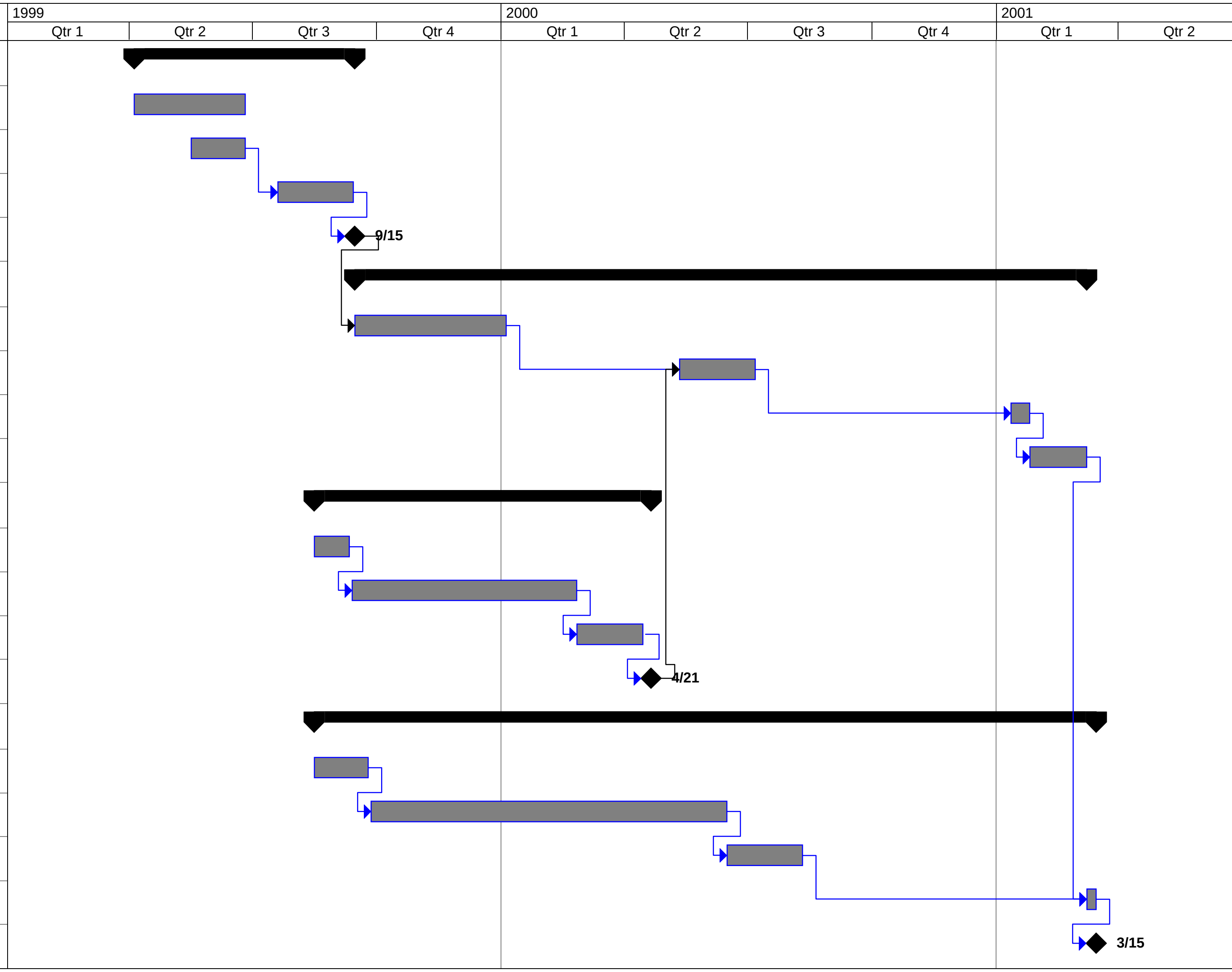
Task | Milestone | Summary

Date: Mon 7/27/98

- DRAFT-

Multiple (10) SNCR Retrofits - Staggered Installations (Unit 8)

ID	Task Name
1	**Facility Engineering Review and Award of Contract (All Units)**
2	Engineering Assessment of Technologies
3	Develop and Send Request for Bids
4	Receive /Review/ Negotiate Bids
5	Award Contract to Technology Provider
6	**Control Technology Installation (Unit 8)**
7	Engineering/Fabrication/ Delivery
8	Construction : Pre Hook-up
9	Construction : Control Device Hook-up (Equipment Outage)
10	Control Technology Testing
11	**Construction Permit (Unit 8)**
12	Permit Application -Preparation and Submission
13	Construction Permit - State Review and Draft Approval
14	Construction Permit - Public Comment
15	Construction Permit Approval (final)
16	**Title V Operating Permit Modification (Unit 8)**
17	Title V Permit Application Preparation and Submission
18	Title V Permit Application - State Review
19	Title V Permit - Public Comment
20	Initial Compliance Stack Testing
21	Title V Operating Permit Modification

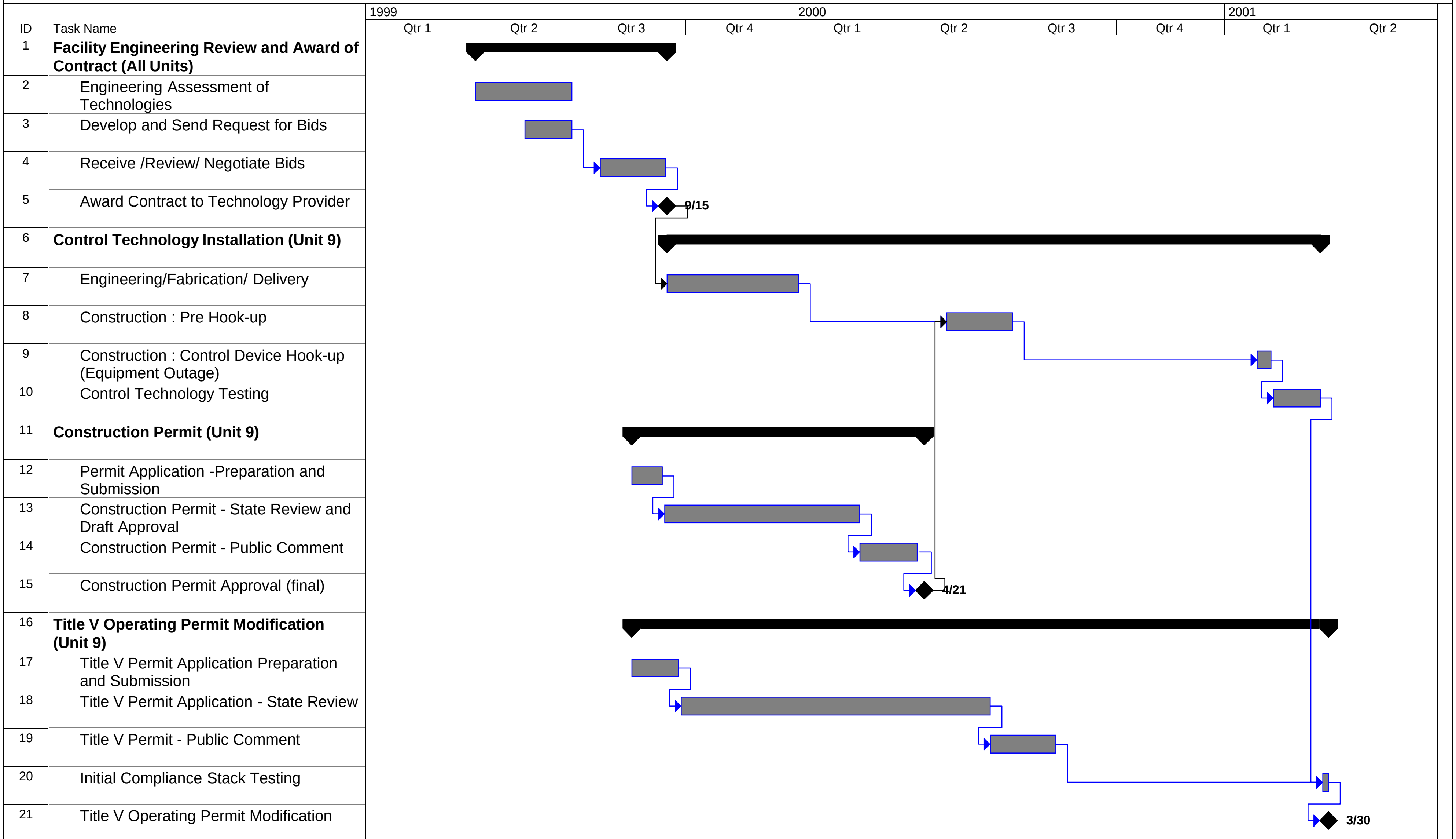


Task | Milestone | Summary

Date: Mon 7/27/98

- DRAFT-

Multiple (10) SNCR Retrofits - Staggered Installations (Unit 9)



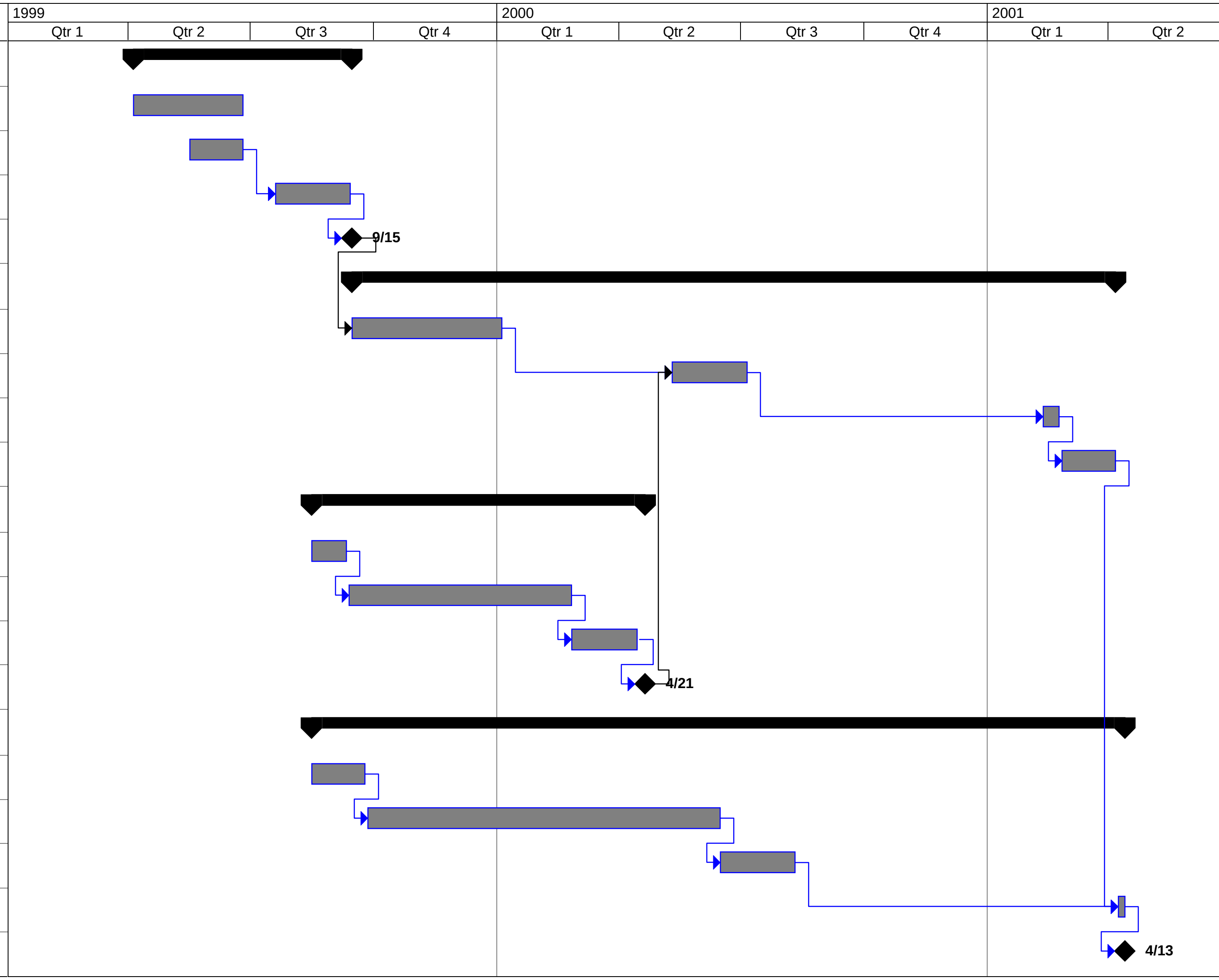
Date: Mon 7/27/98

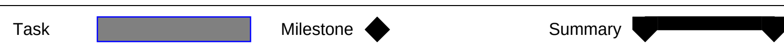
Task | Milestone | Summary

- DRAFT-

Multiple (10) SNCR Retrofits - Staggered Installations (Unit 10)

ID	Task Name
1	**Facility Engineering Review and Award of Contract (All Units)**
2	Engineering Assessment of Technologies
3	Develop and Send Request for Bids
4	Receive /Review/ Negotiate Bids
5	Award Contract to Technology Provider
6	**Control Technology Installation (Unit 10)**
7	Engineering/Fabrication/ Delivery
8	Construction - Pre Hook-up
9	Construction :Control Device Hook-up (Equipment Outage)
10	Control Technology Testing
11	**Construction Permit (Unit 10)**
12	Permit Application -Preparation and Submission
13	Construction Permit - State Review and Draft Approval
14	Construction Permit - Public Comment
15	Construction Permit Approval (final)
16	**Title V Operating Permit Modification (Unit 10)**
17	Title V Permit Application Preparation and Submission
18	Title V Permit Application - State Review
19	Title V Permit - Public Comment
20	Initial Compliance Stack Testing
21	Title V Operating Permit Modification





Date: Mon 7/27/98

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APPENDIX B

Communication Number 1

TELEPHONE RECORD

Anup Mangaokar, ICF Incorporated
June 10, 1998

Delaware Department of Natural Resources and Environmental Control (DNREC)
Tom Lily
(302) 739-4791

Subject: Construction and Operating Permit Processes

Major sources of emissions (such as electric utilities) will have to obtain a permit to construct before installing a new piece of equipment. State review of the permit application can take approximately two months followed by a public comment period. Complexity of the permit application may result in additional delay. Since the Title V operating permitting process is relatively new, the time frame for the modification of the a Title V permit cannot be predicted. DNREC may roll the permit to construct into the Title V operating permit after DNREC's satisfactory review of the entire permit application package and EPA's approval.

TELEPHONE RECORD

Anup Mangaokar, ICF Incorporated
June 10, 1998

Maryland Department of the Environment (MDE)
Dave Mummert
(410) 631-3000

Subject: Construction and Operating Permit Processes

Major sources of emissions (such as electric utilities) will have to obtain a permit to construct before installing a new piece of equipment. State review of the permit application can take approximately three months followed by a public comment period. Facility specific issues may impact the duration of the review period. MDE may issue an interim State operating permit until the Title V operating permit is modified in order to facilitate quicker start-up of the constructed equipment. The Title V permit modification application can be submitted to the State simultaneously with the permit to construct application. Title V permit will be modified only after the satisfactory review of the permit modification application by MDE and EPA. A fairly straightforward Title V modification process can take approximately six to seven months from the date of application submittal.

TELEPHONE RECORD

Anup Mangaokar, ICF Incorporated
July 14, 1998

Indiana Department of Environmental Management (IDEM)
John Akin
(317) 233-0178

Subject: Construction and Operating Permit Processes

Major sources of emissions (such as electric utilities) will have to obtain a construction permit before installing a new piece of equipment. State review of the permit application can take approximately three months followed by a month of public comment period. For an installation of only a control device (without making any other physical or operational modification(s) that would result in increase in emissions), the permit review process is likely to be conducted in a shorter time frame. IDEM will modify Title V operating permit after the satisfactory completion of the State review of the construction and Title V modification permit applications and public comment period. IDEM has not modified a Title V permit so far; therefore, they cannot predict the exact time period for the modification of a permit. Due to current uncertainties associated with the NOx SIP Call, the time frame associated with its implementation in the State of Indiana and associated permitting process cannot be predicted.

TELEPHONE RECORD

Jamie Pierce, ICF Incorporated
July 20, 1998

Kentucky
Bill Diels
502-573-3382

Subject: Process and Time Required to Obtain a Construction and Operating Permit

How long does it take to get a construction permit?

He said that the regulatory time frame is 210 days, but the usual time is 120 - 150 days.

How is the construction permit process handled with a significant Title V modification? Will it be rolled into the Title V permit directly or have an interim permit?

He said that it depends on the status of the Title V permit. If the permit is not approved, they would issue a separate permit to authorize construction. If the Title V is approved, it would be processed as a significant revision, and they would issue a revised Title V permit which would include an authorization for construction. A public comment period would be held after the revised Title V, and then a facility would have the authorization to construct.

Can a facility start construction and operating permits at the same time (to avoid two public comment periods)?

With a revision to a Title V approved facility, there would only be one comment period. With a non-Title V approved facility, there would be two separate public comment periods. The time period is still expected to be 2 10 days for revision to Title V for a significant modification.

TELEPHONE RECORD

Jamie Pierce, ICF Incorporated
July 20, 1998

New Jersey
Jim Marinucci
609-984-3022

Subject: Process and Time Required to Obtain a Construction and Operating Permit

How long does it take to get a construction permit?

He said that for a significant modification, the rule indicates a 12 month time period. The actual time may be a lot less or more depending on the type of modification.

How is the construction permit process handled with a significant Title V modification? Will it be rolled into the Title V permit directly or have an interim permit?

He said that currently the process involves obtaining a preconstruction permit, then an operating permit. Since there are only three to four Title V permits in New Jersey, the process has not been attempted. To this point, changes with Title V permits have been insignificant. When the Title V permit is approved, the preconstruction will be rolled into the permit. A facility can start 11construction at risk" and have the preconstruction permit issued before the Title V permit.

Can a facility start construction and operating permits at the same time (to avoid two public comment periods)?

He said that the state can issue a preconstruction permit prior to Title V approval. The state can do a preconstruction and operating permit at the same time by combining them into the Title V application. This would only require one public comment period. The expected timeline for preconstruction and operating permit is 12 months including the public comment time.

TELEPHONE RECORD

Dib Paul, ICF Incorporated
August 21, 1998

New Jersey Department of Environmental Protection (NJDEP)
Jim Marinucci
(609) 984-3022

Subject: Time Required to Obtain a Construction and Operating Permit for Modifications Resulting from NOx SIP Call

A preconstruction permit is required for units not included in Title V pen-nit. Once a unit is included in the Title V permit, a preconstruction permit is not required. The modification would occur under the Title V operating permit program.

For NJDEP to process the application, typically it would take 3-6 months for industrial boilers and 6-12 months for utility boilers. For a significant modification to a Title V permit, public participation is required. A pre-draft version would be submitted for public review. In addition to the application processing time, NJDEP needs to give the public 30 days to review. Plus, EPA may take up to three months to review and approve the application.

It may take NJDEP about 100 hours to review a significant modification application. For a minor modification, about 40 hours of review time is required.

TELEPHONE RECORD

Dib Paul, ICF Incorporated
August 21, 1998

Connecticut Department of Environmental Protection
Rick Pirolli
(860) 424-3000

Subject: Time Required to Obtain a Construction and Operating Permit for Modifications Resulting from NOx SIP Call

Three to four months of review time for a construction pen-nit is required for major sources. A Title V review will take less time since review will have occurred under construction permit. The key time factor would be EPA's review time. Public participation may not be required for a construction permit, but public review time may be required for Title V changes. He was uncertain how they would handle all this.

Permit application review time is highly dependent on the technology chosen. For example, if SCR or SNCR is chosen it will take less time to review the permits since these are established technologies; however, if a combined technology is chosen it will take at least 50% more time for each additional retrofit.

TELEPHONE RECORD

Dib Paul, ICF Incorporated
August 21, 1998

Maryland Department of Environment
George Ikhinmwin
(410) 631-3246

Subject: Time Required to Obtain a Construction and Operating Permit for Modifications Resulting from NOx SIP Call

In Maryland, it would take about three months to process an application for affected electric utilities and industrial boilers. If the permit application is complete and an established technology (such as SCR) is used, it may take less than three months. Also, processing time would depend on the department's work load at that point in time.

Communication Number 2

TELEPHONE RECORD

Elizabeth Nixon, ICF Incorporated
July 15, 1998

Institute of Clean Air Companies
Ed Campobendetto
202-457-0911

Subject: SCR Catalyst Suppliers

He said that there are currently eleven suppliers of SCR catalyst worldwide. He also mentioned that several other companies may be able to produce SCR catalyst fairly easily because they either formerly manufactured SCR catalyst or currently manufacture other types of catalyst. Mitsubishi and Hitachi supply a majority of the market in Japan, and Seimans serves most of the German market.

Based on his discussions with SCR catalyst manufacturers, he estimates that one process line can produce approximately 2,500 m^3/yr of catalyst with one shift or approximately 3,000 m^3/yr or more, if a second shift is added. Facilities could easily add a second process line if the SCR catalyst demand exists. Consequently, facilities with two production lines and two shifts can potentially produce 6,000 m^3/yr of SCR catalyst. Two manufacturers currently have two lines with the estimated capability to produce about 6,000 m^3/yr. Another manufacturer is able to produce more than 7,000 m^3 of SCR catalyst per year.

Communication Number 3

TELEPHONE RECORD

Kevin Blake, ICF Incorporated
5/27/98

U.S. Geological Survey
Deborah A. Kramer
Commodity Specialist
(703)648-7719

Subject: Ammonia Production

Ms. Kramer stated that the 1997 U.S. anhydrous ammonia production was 11,766,930 metric tonnes. This estimate assumes anhydrous ammonia is 82.2% of total nitrogen production.

Communication Number 4

TELEPHONE RECORD

Wojciech Jozewicz, ARCADIS Geraghty & Miller
April 28, 1998

FuelTech
Vincent Albanese
630.983.3242

Subject: Availability of materials for SNCR installation

Urea manufacturing and processing is not a specialized process. Nozzles and piping used for SNCR installations are customary equipment. SNCR system usually takes 2-3 weeks to install.

Communication Number 5

TELEPHONE RECORD

Wojciech Jozewicz, ARCADIS Geraghty & Miller
April 28, 1998

ABB Environmental Systems
John Buschmann
423.694.5223

Subject: Availability of materials for SCR installation

A typical SCR installation on a 500 MW boiler may use approximately 500 tons of steel. European ammonia CEM's are reliable. Other than SCR catalyst, all the components for a typical installation are standard.

Communication Number 6

TELEPHONE RECORD

Ravi Srivastava, U.S. EPA
July 24, 1998

Andover Technology Partners
Dr. James E. Staudt
(978) 683-9599

Subject: Typical Activities During Planned Outages

He noted that typical activities conducted during planned outages (e.g., removal of slag, repair of boiler tubes, replacement/repair of pumps and motors, and overhaul of turbine(s)) at coal-fired electricity generating boilers are not expected to hinder installation of SCR or SNCR technology.

Communication Number 7

TELEPHONE RECORD

Elizabeth Nixon, ICF Incorporated
July 22, 1998

STEAG
Volker Rummenhohl
919-490-9003

Subject: SCR Installations and Associated Outage Times in Germany

He said that the SCR systems were installed in Germany during the normal outage which at the time was approximately three weeks. Now the outages in Germany are more typically three to four weeks every two to three years. An extended outage of about eight weeks occurs every four to five years to overhaul the turbine generators.

SCR was installed on all of the bituminous coal plants (32,000 MW) in Germany. The total German electric generating capacity is approximately 98 GW including hydro and nuclear.

Communication Number 8

TELEPHONE RECORD

Wojciech Jozewicz, ARCADIS Geraghty & Miller
April 29, 1998

Cormetech
Reda Iskandar
919.620.3003

Subject: Availability of SCR catalyst

A typical SCR installation would use 0.6-1.0 m3 of catalyst per MW on coal fired facility, 0.2-0.4 m3/MW on gas fired, and 0.5-0.8 m3/MW on oil fired facility. Producers are constantly reducing the volume of catalyst required per unit size. For example, for gas turbines the initial pitch that used was 4.2 mm, now a pitch of 2.7 mm is used; capacity almost doubled.

There is an ease of increasing production capacity; new kiln can be built in 6 month.

Communication Number 9

TELEPHONE RECORD

Wojciech Jozewicz, ARCADIS Geraghty & Miller
April 9, 1998

Institute of Clean Air Companies
Michael Wax
202.457.0911

Subject: Feasibility of SCR and SNCR

Time required for installation of NOx control systems was discussed. Given an unrestricted supply of necessary hardware and labor, the installation of an SCR system on a single boiler usually takes 1.5 – 2 years. Installation of an SNCR system on a single boiler usually takes between 6 months and 1 year.

Communication 10

TELEPHONE RECORD

Wojciech Jozewicz, ARCADIS Geraghty & Miller
April 28, 1998

Hitachi America, Ltd.
John Calvello
914.631.0600

Subject: Availability of SCR catalyst

A typical SCR installation would use 0.75 – 1. 0 m^3 of catalyst per MW on coal fired. Given the size of an installation, this number could be used to estimate the amount of SCR catalyst. An easy way to increase the capacity of a typical SCR catalyst production line is to operate to on three rather than two shifts.

Communication Number 11

TELEPHONE RECORD

Wojciech Jozewicz, ARCADIS Geraghty & Miller
May 11, 1998

Peerless Mfg.
Co. Peter Burlage
214.357.6181

Subject: Availability of ammonia delivery systems

Normally, a large supplier of SCR systems (or ammonia SNCR systems) would subcontract the manufacture of the ammonia supply system to smaller firms. These firms would use typical components to engineer the complete ammonia delivery system. There are currently up to 3 active ammonia supply systems manufacturing firms and up to 8 ammonia supply system engineering firms in the United States. In addition, there are at least 3 more manufacturing firms that have produced ammonia delivery systems in the past and are capable of a rapid start up of production.

A major producer of ammonia delivery systems is currently capable of providing up to approximately 25 systems per year. Therefore, assuming equal production capacities of 3 currently active firms, approximately 75 systems a year could be currently produced. However, given a sudden surge in demand, this estimated annual production capability could be doubled in a short period of time. In addition, major suppliers of anhydrous ammonia may be likely to provide their own ammonia supply system for the site to operate ("own and operate" arrangement) as a part of the long term contract for anhydrous ammonia.

Correspondence Number 1

NALCO FUEL TECH P.O. BOX 3031 • NAPERVILLE, IL 60566-7031

FAX MEMO

Date: April 8, 1998 # pages including coversheet: 8

TO: Mr. Jozewicz

Phone:

Fax #: 919. 544-5690

CC:

SPECIAL INSTRUCTIONS:

FROM: Vincent M. Albanese
Phone: 630.983.3254
Fax #: 630.983.3240

☐ Urgent ☐ Reply ASAP ☐ For your review ☒ Per your request ☐ FYI ☐ Other

Vince suggested that I fax this latest paper to you regarding your questions.

He is out of town today and tomorrow and we are closed on Good Friday.

I hope this will help you.

Pat Roman

...\mjb\#faxmemo.vma

Technical Background

NFT currently has 17 commercially licensed urea-based SNCR (NOxOUT®) systems retrofit on electric utility system in the U.S., All units except two are in the 37 state OTAG region, and within the "fine grid" area to which the proposed SIP call is directed. NFT also has 70 NOxOUI® projects commercially installed or contracted on US industrial boilers or process units, and 24 systems commercially licensed and installed on municipal waste combustors in the U.S. in each and every case contractual obligations and performance guarantees have been met.

NRT has also installed the first commercial hybrid of urea-based SNCR/down-sized SCR System on a pulverized coal fired utility boiler. Known as NOxOUT CASCADE®, the system utilizes managed, designed levels of SNCR generated ammonia slip as reductant for a down sized NOx reduction catalyst bed located downstream of the SNCR. This system expands the NOx reduction range of SNCR on a specific unit at nominal capital expenditure over SNCR.[1,2]

Implementation Schedule and Framework for Electric Utility NOx Reductions

In EPA's Finding of Significant Contribution and Rulemaking for Certain States in the Ozone Transport Assessment Group Region for Purposes of Reducing Regional Transport of Ozone, Preamble Section I (D)(2)(e) specifically proposes to:

> ...impose an implementation *date* (emphasis added) for required controls of three years from the date of the required SIP submission, which would result in compliance by those sources by no later than September 2002. However, the EPA is soliciting comments on the range of implementation dates from between September 2002 and September 2004. The EPA seeks comment on which *date* (emphasis added) within the two year range is appropriate, in light of the feasibility of implementing controls and the need to provide air quality benefits as expeditiously as practicable ... states be required to meet mandated budgets by the end of the year 2007...

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[1] "Evaluation of Hybrid SNCR/SCR for NOx Abatement on a Utility Boiler", Huhmann, A.& A. Wallace of PS.E,&G., V. Albwew and J. Boyle of NaIco Fuel Tech, Power-Gen, Anaheim, CA, December 7, 1995.

[2] "Commercial Hybrid SNCR/SCR Demonstration" Urbas, J., GFU Generation, Inc. and J. Boyle, Nalco Fuel Tech; DOE/ EPA/EPRI The Mega Symposium, Washington D.C., August 25-29,1997.

Nalco Fuel Tech encourages EPA to consider an alternative approach to that of a single implementation date. With the obvious exception of the statutory requirement for Severe (2) classification ozone non-attainment areas to be in attainment by November 15, 2007, no positive purpose is served by forcing such a sweeping implementation requirement by a single date. Nalco Fuel Tech encourages bracketing a minimum three to four year period forward of EPA's "requirement" to allow affected utilities, technology suppliers (of both equipment and engineering services), and EPA itself an organized way to schedule outages, plan resources and production, and monitor gradual progress in reduction of ambient ozone levels.

A proposed alternative which would benefit boiler owners, technology suppliers, and EPA alike would be to require enforceable early reductions during the minimum three- to-four year bracketed period and, as compensation for the early reductions, allow the reductions to be "bankable" under the forthcoming[3] trading system. The banked allowances can be hold internally for application in the first compliance year or sold to another generation company or large industrial boiler owner.

A proposed implementation step timeline vs. regulatory requirement is shown in Figure 1. Enforceable reduction for the "first-in" units begin in the year 2001, and subsequently more units are captured on an annual ratcheted basis until the compliance date. Such a schedule enables implementation by all affected units by the year 2005, thus enabling attainment demonstration and budget compliance by 2007. This proposed schedule concept yields approximately one year (2000) for the "first-in" units to undergo procurement. In turn, SIP revisions from the States will already have been submitted to EPA, therefore plants will know their requirements by 2000 so procurement can logically be executed.

A. Affected Electric Utilities

The generation companies affected by the proposed SIP call range from small investor-owned companies comprised of a few boilers to extremely large companies with more than twenty boilers and greater than 20,000 MWe installed capacity. In order to install the required technology, outages must be scheduled of the appropriate duration[4] to allow the construction and tie-in of the specific control technology. Also, the timing of the outage must not jeopardize electrical supply reliability and should not unreasonably affect dispatch economics. Outage schedules for maintenance are planned years ahead of time and are constantly

[3] EPA plans to publish a supplemental notice of proposed rulemaking (SNPR) in early 1998. In the SNPR is to be included a proposed model cap and trade rule to be adapted by state authorities.

[4] Installation of NOxOUT® systems is relatively convenient taking approximately two weeks. Cascade hybrid systems can be done in 30 days, but more typically 45 days depending upon catalyst parameters. Full-blown SCR systems would require somewhat longer outage periods depending on retrofit difficulty.

updated. There generally is only one unit outage per year (taken during off-peak demand periods ... typically Fall or Spring) planned for projects the magnitude of NOx controls installation However, the industry trend is to increasingly stretch the period between planned outages, rendering implementation planning more difficult. Considering a two month outage might be required for a specific unit, and considering two off-peak periods generally occur per year, a large generation company has considerable planning issues taking a minimum of three-to-four years to achieve. In order to comply by a date certain, capital expenditures would be financed years before EPA's proposed single compliance date. A small utility, in contrast, requires a shorter bracket of time, perhaps only a year, to implement NOx controls thus delaying capital expenditures relative to the large generation companies. As a parallel issue during the period through which EPA would propose implementation, deregulation of electricity generation and pricing will have occurred on a state-by-state basis to allow non-discriminatory access to the transmission grid for all buyers and sellers of wholesale electricity.[5] With the regulatory development of competing utilities, EPA should consider the equitability of an environmental regulatory requirement that causes large capital expenditure for large generation companies significantly before smaller companies. Permitting owners and operators to bank all emission reductions (both enforceable and surplus) before the conclusion of the bracketed implementation period is a means of compensation for these owners required to incur large cost before their competitors. The sheer number of affected units along with a multi-year implementation schedule can make progress difficult to achieve and monitor. MIA could consider identifying enforceable mechanisms to implement the reductions in the three-to-four year bracket period, along with legally enforceable increments of progress towards compliance (e.g. submission of final control plan, initiation of on-site construction, etc.). An example of such a program is found in 40 CFR Section 60.24(e), Subpart B relative to implementation of MACT-based emission guidelines for Municipal Waste Combustors.[6]

B. Supply Sector

In past NOx rulings, EPA has promulgated one date implementation requirements. Implementation of NOx RACT[7] and acid rain provisions for Group 1 and Group 2[8] boiler NOx controls are examples of such. These one date requirements have spawned questions regarding electricity supply and technology supply. The issue

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[5] FERC, Notice of Proposed Rulemaking 3-29-95 (Docket No. RM95-8-000)

[6] EPA-456R-96-003, Municipal Waste Combustion: Summary of the Requirements for §111(d)/129, State Plans for Implementing the MWC Emission Guidelines.

[7] CAA §172©(1)

[8] 42 U.S.C. 7651f(b)(1)(B)

for the supply sector is not so much capacity to supply equipment, reagents,[9] services and resources as much as increasing cost to the end user, and risking the continued health (fiscal) of the supply sector. Implementation by one date leads to chaotic procurement practices by some buyers, and a greater percentage of time-of-the-essence contracts. This behavior results from the clear fact that a business will not expend capital before it is required. Under "rush" conditions subcontractors charge premium rates and those costs are passed on to the buyer. With time of the essence contracts prices rise to account for the owner's position of demanding additional liquidated damages from the supplier for not meeting the fight schedules. Overall, the total capital requirement to the boiler owner can increase 20-40%.

Another consequence of single date implementation is technology companies are extremely difficult to manage profitably when pollution control requirements are implemented in "spikes" with no market activity for in-between years. A continuum of market activity (not to be confused with more market activity or more stringent requirements) allows smarter management of the supply sector companies, as well as maintain the technological ability of companies themselves. That is, greater market continuity helps to prevent losses of highly skilled employees to more steadily producing technical businesses ("brain drains") during the "off" years of air pollution control business. Clearly, in order for EPA and affected parties to do their jobs, a reasonably healthy supply sector is needed.

C. EPA and State Agencies

EPA faces the daunting technical and political challenge to issue regulations and policy for attainment of ambient ozone concentration standards through use of UAM-V and other computational means. As sophisticated as these methods are, and as skillful as its practitioners are, EPA itself estimates the proposed SIP call to have an annual $2,000,000,000 effect on the economy. It would seem prudent to

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[9] NFT has been approached by EPA concerning the ability to supply its technologies to the electrical utility industry and non-utility industrial sources. As required by its agency agreement with EPRI, NFT has six licensed implementors who may design, make, sell and install NOxOUT® SNCR systems. The implementors are large, respected engineering companies with history in the air pollution control industry.

Urea supply is sufficient to satisfy the prospective demand from EPA's proposal without difficulty. Hypothetically, if the proposed 1.1 mm ton NOx reduction was achieved solely by NOxOUT® or NOxOUT CASCADE®, only 15% of the 12,000,000 dry ton domestic supply of urea would be consumed. Furthermore, urea is a global commodity whose domestic price and supply is maintained by trade balance. The U.S. is a minor global producer, and imports its urea raw material as a matter of course. American manufacturers and diw1utors routinely trade within the 130,000,000 ton global capacity of urea, which produces at 79% capacity (Fertecon source).

construct a more gradual and refined implementation schedule which permits, monitoring and recording of decreasing ozone exceedances throughout the fine grid region as time moves towards the final compliance date. The gradual reduction of regional NOx towards the budget goals serves as a checkpoint for modelers to further assess and refine programs, and EPA to refine policy, towards the ultimate goal of attainment.

Applicability of SIP Call Requirements Towards Municipal Waste Combustors

Nalco Fuel Tech seeks clarification on conflicting indications regarding applicability of proposed SIP call provisions to Municipal Waste Combustors.

In the Regulatory Analysis to the proposed SEP call the EPA proposes to establish a summer reason NOx emissions budget for 22 states and the District of Columbia based on reducing NOx emissions from electric power industry and Other stationary sources, among other sectors. In a footnote,[10] EPA identifies, the "Other" category by citing source subcategories such as industrial, commercial, and institutional boilers, reciprocating engines, gas turbines, process heaters, cement kilns, furnaces at iron, steel, and glass-making operations, and nitric acid, adipic acid and other plants with industrial processes that produce NOx. Nowhere in this footnote are municipal waste combustors mentioned.

Yet, the OTAG Control Technology and Options Workgroup, whose work formed the basis of control levels to be implemented on Other (non-utility) sources, issued a support article entitled "Assessment of Control Technologies for Reducing Nitrogen Oxide Emissions from Non-Utility Point Sources and Major Area Sources"'. The section regarding the universe of sources enumerates many source types and lists them in order of emission contribution to the NOx inventory, The document proposes truncating the affected categories after the ninth largest category thereby accounting for 87% of all non-utility point source and area source NOx contributions. The remaining categories were not -considered due to their relatively small contributions. The Prioritized Contribution of NOx Source Categories from EPA's Tier 3 Summary lists incineration as the ninth largest category contributing 148 TPD NOx in a summer day. The Waste Incineration category includes municipal, medic4 hazardous and sewage sludge incineration. NOx control methods for these sources include post-process controls (e.g. $NCR). Treatment of incinerators in this document strongly points to inclusion in the state budgets.

[10]10 Preamble Section VIII, Pg. 80, note 23.

The basis for inclusion in state NOx budgets for Other stationary sources is found in Section HLB(2)(b) "Determining the Cost Effectiveness of NOx Controls". EPA, in proposing 70% NOx control for large-sized industrial sources (e.g. greater than 250MM Btu/hr), categorizes large industrial sources as sources emitting 2 tons/day NOx during ozone season where medium-sized sources (proposed to be subject to RACT) are categorized as emitting between 1 and 2 tons/day NOx during the summer.

EPA, in December 19, 1995, promulgated Emission Guidelines"[11] for existing Municipal Waste Combustors which limits emissions of acid gases, particulates, toxic heavy metals, dioxins, carbon monoxide and NOx based upon the statutory definition [12] of Maximum Available Control Technology. The guidelines reflect a MACT standard for NOx at 205 ppm for mass burn waterwall MWC's and 250 ppm for Refuse Derived Fuel fired MWC's. Applications of the MACT limit, to be met no later than December 19, 2000, to affected MSW facilities (essentially 250 TPD minimum up to 3000 TPD of N4SW) embodies an emission range of 0.4 TPD NOx to >2.0 TPD NOx. (See Appendix A). The affected population includes 81 facilities requiring significant retrofits. [13] Facilities slightly larger than 1000 TPD fit the criterion of emitting more than 2 TPD NOx.

Nalco Fuel Tech as of this writing has installed commercial SNCR systems on 24 domestic municipal waste incinerators. Permit levels to be met have been as low as 80- 124 [14,15,16] ppm. Maximum performance tests in the field show 75 ppm is an easily achievable commercial emissions limit.

Nalco Fuel Tech respectfully requests clarification regarding MWC inclusion in the proposed budgets for the year 2007 Non-Utility Point Sources for states in the Fine grid.

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[11] 40 CFR 60 Subpart C_b

[12] CAA §112 (d)(3)(A,B)

[13] EFA456-96-003, Municipal Waste Combustion: Summary of the Requirements for §111(d)/129, State Plans for Implementing the MWC Emission Guidelines.

[14] Hofmann, J. B., W. H, Sun, et al, "NOx Control For Municipal Solid Waste Combustors" A. & W. M. A. Annual Meeting, June 24-29,1990.

[15]Intercompany Communication, "Bechtel SEMA$$ Expansion Project NOxOUT® System Startup And Optimization Report."

[16] Recchla, C. of CRRA, and V. M. Albanese, & A. S. Dainoff of NFT, "System-Wide NOx Control Strategy for CRRA", presented at ICAC Clean Air Forum, Baltimore, MD, March 19, 20, 1996.

<u>Appendix A</u>

Assumptions:

4800 Btu/lb. of MSW
F_d = 9570 dscf/MBtu

1. 250 TPD, 205 ppm dvc @ 7% O_2
   100 mm Btu/hr., 1.44 mmscfh flue gas @ 7 % O_2
   35.2 lb. /hr. NO_x: <u>0.423 TPD NO_x</u>

2. 1000 TPD MSW, 205 ppm dvc 7% O_2
   400 mm Btu/hr., 5.76 mmscfh flue gas @ 7% O_2
   141 lb./hr. NO_x: <u>1.692 TPD NO_x</u>

3. 1500 TPD MSW, 205 ppm dvc 7% O_2
   600 mm Btu/hr., 8.63 mmscfh flue gas @ 7% O_2
   211 lb./hr. NO_x: <u>2.54 TPD NO_x</u>

4. 1000 TPD MSW, 205 ppm dvc 7% O_2
   417 mm Btu/hr., 5.64 mmscfh flue gas @ 7% O_2
   169 lb./hr. NO_x: <u>2.02 TPD NO_x</u>

OZONE TRANSPORT IMPLEMENTATION
PROPOSED TIMELINE

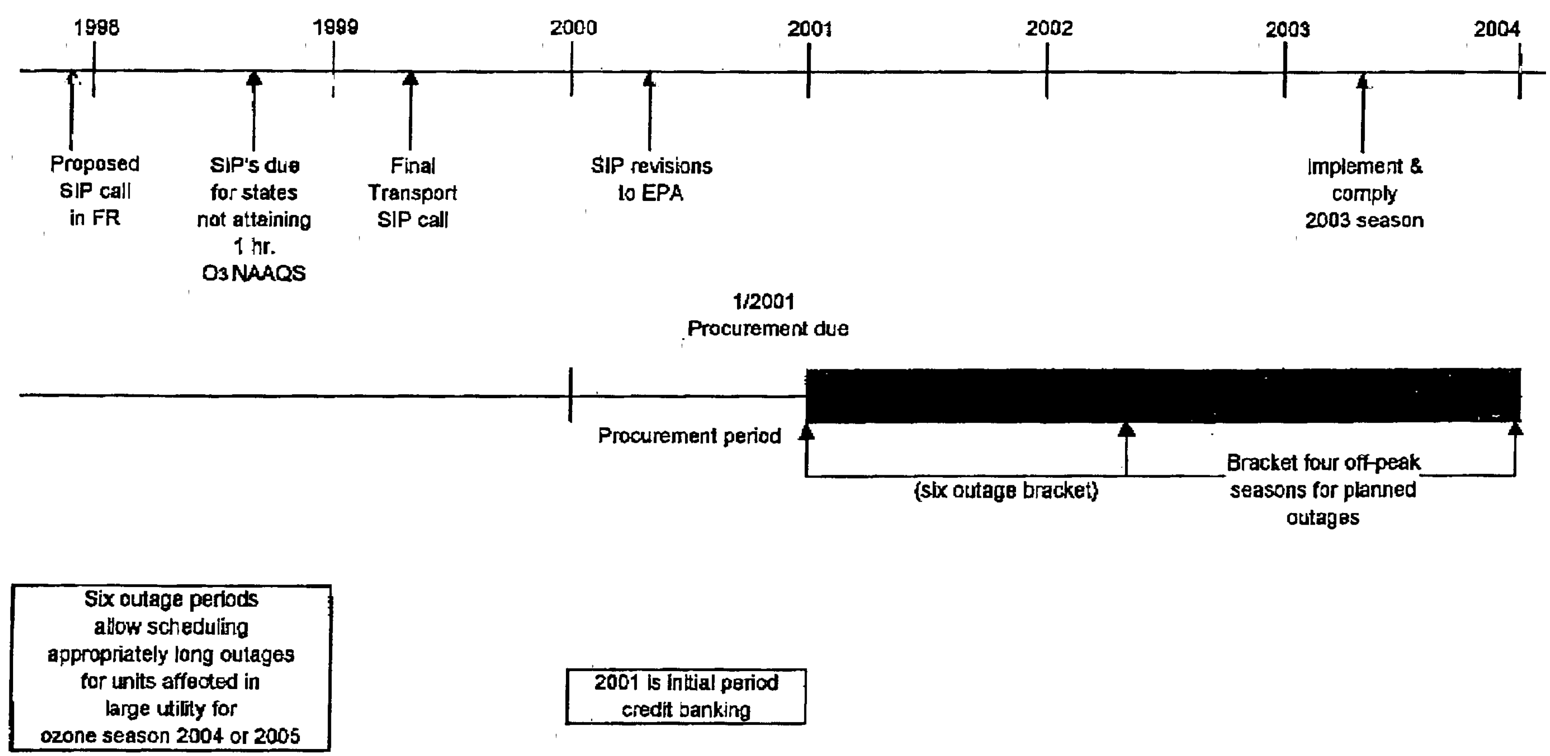

Figure 1

Correspondence Number 2

Environmental Engineering and Consulting

steag
Aktiengesellschaft

STEAG Aktiengessellschaft
Liason Office:
3715 University Drive
Durham, NC 27707
Phone (919) 490-9003
Fax (919) 402-0071
Email 100322.1530@compuserve.com

August 24, 1998

Mr. Ravi Srivastava
United States Environmental Protection Agency
401 M Street, S.W. Mail Code 6204J
Washington, D.C. 20460

Dear Mr. Srivastava:

Lately a lot of discussions in the SCR field revolve around the necessary outages to connect an SCR system to the existing boiler. Since these discussions are very divergent I would like to share with you some of my experience in Germany and the United States.

I was involved in one respect or another in a total of approximately 10,000 MW of SCR retrofits in Germany for a system supplier. The shortest connecting time we needed to start up an SCR unit was an extended weekend outage. The entire plant had been built during regular boiler operation. The connection of the control and electrical system were done during scheduled annual outages prior to the commission of the SCR plants. During the scheduled annual outage a flue gas duct part had been placed between economizer outlet and airheater inlet including bypass and inlet and outlet dampers. This is a common way to build SCR plants and it secures that outages of not more than two to four weeks are necessary to integrate the SCR.

All of STEAG's outages for the integration of the SCR were less than four weeks. The New Madrid project is a retrofit of an SCR plant including a new airheater on a 600 MW coal fired unit. The owner is Associated Electric. The guaranteed outage time will be six weeks including the demolition of an airheater. There will be a second planned annual outage one year later to connect the plant. It is always possible to stretch outage work over two or three outages.

I thought that this may be useful information for you. If you have any questions please don't hesitate to call.

Best Regards,
Volker Rummenhohl

Volker Rummenhohl,
Manager, North America.